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ABSTRACT

Technology--the use of knowledge, tools, and skills to solve practical problems and extend human capacities--can be beneficial to the Texas school system. In fact, Texas state-level decision-makers in recent years have shown increased interest in potential technological applications for meeting the state's educational needs. Recently developed programs reorganize classrooms into learner-centered environments that can make efficient use of new technological innovations in basic skill instruction. As essential numerical tools, computers have great potential to aid, and in many cases transform, traditional mathematics education and create new ways of learning. With the assistance of electronic mail, the telephone, vidoetext, and audio teleconferencing, rural schools with limited resources can offer additional curriculum and provide better instruction, while avoiding the inconvenience of school district consolidation. The degree of teacher autonomy, and the quality of teacher training at both the preservice and inservice levels, will be a major influence on the adoption, implementation, and success or failure of new technologies in education. A review of the advantages and disadvantages of available finance options is included. (190 references) (KM)

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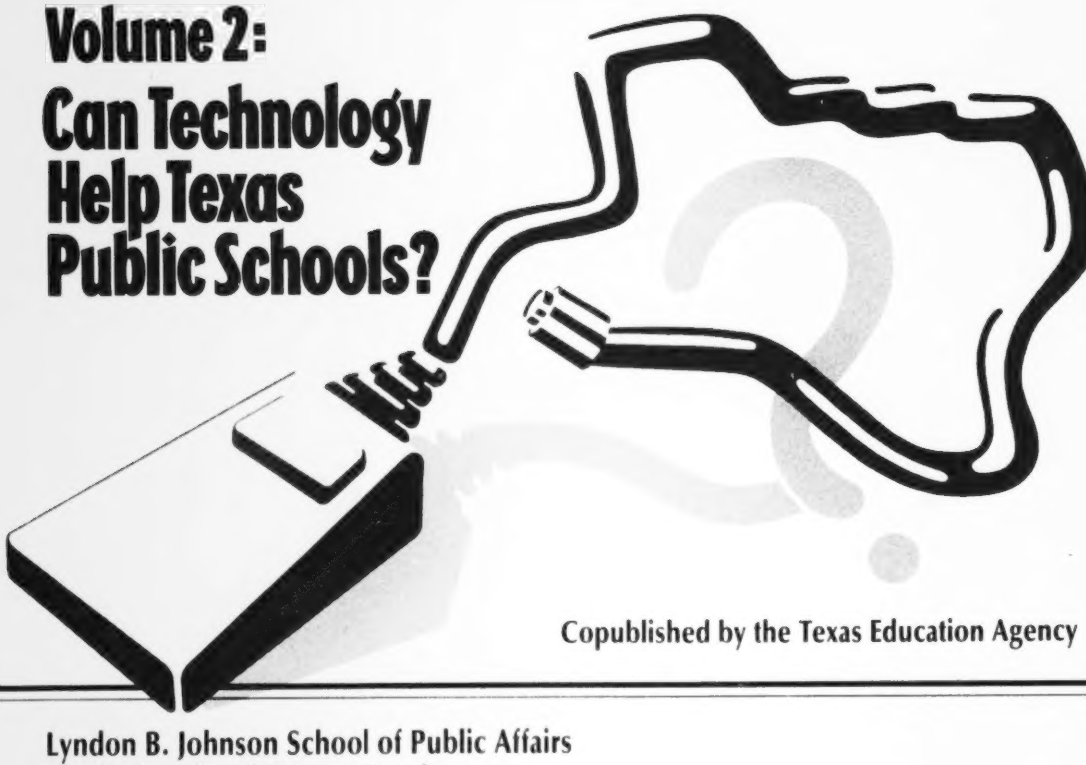
Volume 2:

Can Technology Help Texas Public Schools?



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The University of Texas at Austin
Policy Research Project Report

85

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Policy Research Project Report
Number 85

Education, Technology, and the Texas Economy

Volume 2
Can Technology Help Texas Public Schools?

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Foreword

The Lyndon B. Johnson School of Public Affairs has established interdisciplinary research on policy problems as the core of its educational program. A major part of this program is the nine-month policy research project, in the course of which two or three faculty members direct the research of ten to twenty graduate students of diverse backgrounds on a policy issue of concern to a government agency. This "client orientation" brings the students face to face with administrators, legislators, and other officials active in the policy process, and demonstrates that research in a policy environment demands special talents. It also illuminates the occasional difficulties of relating research findings to the world of political realities.

In the summer of 1987, the Texas Education Agency enlisted the Lyndon B. Johnson School of Public Affairs in such a project and began a joint effort to examine the relationship between public education and the economy of Texas. Professors Ray Marshall, John Gronouski, and Robert Glover and students at the LBJ School worked closely with TEA staff in the Division of Research and Information to examine the relationship between the Texas public schools and the economic future of the state. The result of this joint effort is a series of reports concerning education, technology, and the economy.

The first of these reports, Economics of Education, by Professor Ray Marshall, focuses on current economic and demographic trends in Texas and their implications for public education. This report is followed by two additional volumes prepared by students and edited by Robert Glover and John Gronouski, addressing the issues of technology and the Texas public schools and vocational preparation and the Texas economy.

These reports provide an excellent resource for all of those engaged in the public debate surrounding education and the future of Texas. It is the hope of the LBJ School, the State Board of Education, and the Texas Education Agency that this report will enlighten and inform all of those involved in the policymaking process.

Finally, it should be noted that neither the Texas Education Agency, the LBJ School, nor The University of Texas at Austin necessarily endorses the views or findings of this study.

WNKirby

W.N. Kirby
Commissioner of Education

Max Sherman

Max Sherman
Dean

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We also wish to thank several individuals who took time from their busy schedules to travel to Austin and meet with us on various aspects of this fascinating subject, including Roy Amara, President, Institute for the Future; Anthony Carnevale, Vice President and Chief Economist, American Society for Training and Development; Francis Dummer Fisher, Consultant to the PERSEUS project of Boston University and Harvard; Larry Jenkins, Chairman of the Texas Select Committee on Education; Henry Kelly, Office of Technology Assessment, U.S. Congress; Robert Taggart, President, Remediation and Training Institute; and Marc Tucker, president of the National Center for Education and the Economy.

Literally hundreds of people, both in Texas and elsewhere, were consulted or interviewed for this project. Although we cannot name them all here, we wish to thank them for their contributions.

Thanks are also due to Jeanette Paxson and Maria Martinez of the LBJ School Publications Office for their expeditious assistance with editing and production of the publications.

Finally, we want to remind the reader that any remaining errors in the reports are the responsibility solely of the authors.

Executive Summary

Can Technology Help Texas Public Schools? To most observers, the answer to the question posed in the title of this report is an obvious and emphatic "yes!" Clearly technology has a favorable image in American society, given its association with progress and a better future. Yet the matter is not as simple as that. When most people think of technology, the image of a computer comes to mind. But technology is more than that. Broadly defined, *technology* means the use of knowledge, tools, and skills to solve practical problems and extend human capabilities. Technology is not simply equipment for equipment is no more than embodied knowledge.

Merely installing computers in classrooms across Texas will not improve education without well-trained teachers, effective planning regarding how these technological tools will be used, high-quality software, and reliable system maintenance. Computers are not self-implementing.

More important, instructional technology needs to be better integrated with the educational process. We need to better understand the teaching and learning processes. We also need to focus on the learning system as a whole and the incentives for learners, teachers, and administrators. Equipment such as computers, software, video cameras, and satellite dishes are no more than tools. One does not teach a man to be a carpenter simply by handing him a hammer and a saw. Attention needs to be devoted to training in how to use the tools. At this point, the subject becomes a little more complex. Reasonable people differ on issues of, for example, how to use computers in the instructional process.

It is becoming clear that there is no "one best way" to learn or teach. In fact, individualizing learning implies providing teachers with a variety of teaching media and approaches. In this way, technology *extends* teachers rather than *replacing* them.

The application of technology to education offers several potential benefits. Many believe that technology can provide a cost-effective means of delivering an array of educational services tailored to the educational needs of rural schools as well as students who are handicapped, disadvantaged, other otherwise at risk. Second, educational technology is seen as a tool to enhance the pedagogy of educational programs, making lessons more effective, interesting, and accessible. Third, learning about the technology itself will be imperative in a world where technology is a major and rapidly changing force in the world economy. Fourth, the application of technology to instruction has the potential to help resolve problems in the labor market for teaching by enhancing the attractiveness of the teaching profession. New technologies will likely change the role of teachers and call for greater use of teachers' aides.

In recent years, state-level decisionmakers in Texas have shown increased interest in the potential applications of technology in meeting the state's educational needs. In 1986, computer literacy was made a requirement for all junior high school students and knowledge of information processing was made a graduation requirement for all prospective teachers. Discussions are underway regarding the future role of the state in promoting and coordinating technology usage. TEA, under the aegis of state Board of Education and with the assistance of an advisory committee, has developed a long-range plan for technology. In a separate but related effort, a software advisory committee has been created that reports to TEA's Division of Educational Technology. A major program entitled the Texas Learning Technologies Group has been initiated by the Texas Association of School Boards; the pilot program features the use of computer-based interactive videodisk technology for teaching the physical sciences. Although the state plays the major role in the areas of certifying teachers and teacher training programs, most decisions regarding classroom technology currently are made at the district, school, or classroom levels.

This report deals with the application of new technologies in three areas: basic skills, higher mathematics, and distance learning. It then turns its focus to the subject of teacher preparation to work with the new technologies. Teacher training is a key to successful implementation of technology in education. In fact, properly conducted, it is probably more expensive than the initial capital cost of most equipment. This report examines various approaches to effective teacher preparation. Finally, the report considers the issues of governance and financing of the new technologies. It reviews how other states manage and finance technology and concludes with a description of the various options available to Texas policymakers.

NEW TECHNOLOGIES TO TEACH THE BASIC SKILLS

Basic skills have long been the primary area of application of computers to instruction. For the past 20 years, computer -assisted instruction (CAI) has made available various software for drill and practice and tutoring in basic skills. Overall, the research demonstrates that CAI increases the efficiency of learning.

But recent new developments that go beyond the simple use of computers in CAI are now available. These new programs reorganize classrooms into new learning environments of which computers are only one of several types of learning stations. These new systems make use of the research on learning and on effective schools to construct learning environments which can make effective use of the new technological tools. These environments are learner-centered rather than teacher-centered. They offer a practical means to move beyond group instruction dominated by lectures and textbooks to an individualized, self-paced learning approach that makes use of multiple instructional media.

Two examples of these new approaches are the Comprehensive Competencies Program (CCP) and IBM's Writing to Read Program. Both of these innovations are learning *systems* -- which offer excellent illustrations of the full meaning of the term "technology"-- not just the use of equipment.

THE USE OF COMPUTERS IN TEACHING HIGHER MATHEMATICS

Mathematics is a troubled subject area in American education. American high school seniors ranked 14th among 15 industrialized countries on recent tests of mathematics. This has grave implications for our nation in an international economy driven by technological change.

The computer's power to perform vast numbers of calculations instantaneously empowers mathematics learning. As essentially numerical tools, computers have great potential not only to aid traditional mathematics education but in many ways transform it and create new ways of learning. Beyond creating electronic versions of drill book exercises, a computer can serve as a diagnostic tool for identifying students' errors. Such software exists for arithmetic and there is promising material available for algebra, though it is more difficult to produce.

Though the importance of understanding basic arithmetic can not be understated, the ubiquity of calculation devices in everyday life make spending large amounts of time on complicated arithmetic manipulations unnecessary. Time could be better spent on understanding common mental tasks such as estimation and appreciating the relative magnitudes of different numbers. Fundamental properties, of course, remain important.

Continued resistance to the use of calculators in classrooms does not bode well for integrating computers into the curriculum. A prevalent attitude is that extensive drill exercises done by hand are the only path to fully understanding the material and that this develops an important outcome of mathematics learning, precision and accuracy. Arguably though, working with computers fosters the same skills.

Students that perform poorly may be able to catch up through individualized computer instruction and break through tracks of advancement which have isolated groups of students according to the ability they showed in early grades.

Too much time is currently spent on performing complicated manipulations for a narrow group of problems which fit a certain few patterns in order to yield answers. It is questionable whether students are learning the subject matter or merely rote methods. By firmly establishing the principles, computers can serve as springboards for accelerated learning, teaching topics whose main barrier to understanding has not been the concepts but the amount of calculations involved. Examples include systems of equations and statistics. Spreadsheets are an excellent general purpose tool for teaching mathematics. They allow manipulations of complicated equations, even matrices and their graphing ability offers a different way to look at and understand symbolic equations. This dynamic illustration of subject matter suits some students better than traditional pencil and paper exercises.

The graphic medium blurs the line between hierarchical divisions of subjects. Algebra, geometry, trigonometry and calculus have interdependent relationships based on forms and shapes. With their ease of calculation and instant illustrations, computers can bring together these topics and allow understanding at earlier grade levels. The computer's graphic powers are especially relevant to geometry.

Computers permit the teaching of real mathematical applications, instead of the artificiality of word problems so often used. Cross subject matter includes economics and social statistics as examples. Most exciting, though, are simulations and the illustration of scientific phenomena. Mathematics has often developed for the purposes of scientific modeling.

Current attempts at integrating computers into the curriculum often result in hybrid courses, such as teaching programming with assignments requiring illustration of mathematical concepts. Such courses may use the computer as an end in themselves rather than as a tool in an enhanced curriculum. They often cover topics better taught in true mathematics classes. Full integration of computers into mathematics curricula offers new opportunities-- not just more efficient ways of doing the same things. Computer courses should fundamentally be independent of mathematics curricula; computer courses should concentrate on programming, information systems, applications, foundations of the technology, and social implications.

The prospects for computer-integrated curricula for high school and upper-level elementary mathematics are too advantageous to be ignored. To fulfill the potential of computers in the teaching of mathematics, proper resources are required. No special hardware is required; a single computer with a high-quality monitor will suffice for many techniques, though a laboratory of work stations is necessary for exercises. Proper software and textbooks are more difficult to procure. Software will require more intensive simulations and applications, and should be of a higher, more integrated quality, especially in graphics. Incorporation of computer applications and techniques should accompany the use of textbooks. Given the time necessary to develop and implement new textbooks, alternative instructional materials may be needed. Traditional materials can be augmented through informal and formal networks, providing sharing and dissemination of BASIC programs, spreadsheet models, creative applications, and new ways of presenting material.

Applications across subject material, linking to topics in science and social studies should be encouraged and, when possible, coordinated for mutual benefit. Also encouraged should be the teaching of topics not usually taught in high school -- such as statistics and linear programming -- which are made possible with computers.

The issue of how much work in complicated manipulations is necessary for comprehension begs for further inquiry. However, this should not impede those willing to fully integrate computers into the curriculum. Full integration has implications for curriculum structure and for the measurement of achievement. Flexible hierarchies would allow classes to move at their own pace. There should be several levels so students could find a pace with which they are comfortable. Traditional options should remain for those prefer them. Flexible hierarchies circumvent traditional, grade-by-grade, subject-by-subject ladders of achievement by placing less distinction between topics and often combining them. Alternative ways of measuring achievement, perhaps testing for credit, may be necessary.

Demonstration projects could point out the strengths and difficulties of a computer-integrated approach. Such projects would probably work best in larger schools, possibly ones with a mathematics specialty. Participation should depend on the inclination and resources of a school. Though computer-integrated curricula may work best with students able to work at an accelerated pace, such curricula should not be reserved for the elites. Full effort must be made to develop and test techniques for less advanced students, including those who have difficulty mastering mathematics.

DISTANCE LEARNING

Through the use of distance learning, rural schools with limited resources can offer additional curriculum and provide better instruction, while avoiding the hardship and inconvenience of school district consolidations. Various types of distance education include the use of electronic mail, the telephone, videotext, and audio teleconferencing. Perhaps the most exciting innovations in delivery systems have occurred with the use of satellite programs and interactive television.

In the past few years, Oklahoma State University, Utah State University, Eastern Washington University, the state of Minnesota, and TI-IN all have developed satellite networks that have changed the manner in which many students in rural areas are receiving instruction. States are presently experimenting with distance learning programs via satellite include Oklahoma, Arkansas, Missouri, New York, Minnesota, Alaska, California, and Texas.

Generally, evaluations of satellite programs have shown favorable results in students' learning. Those students who are self-motivated tend to perform better than less motivated students. Many students need more feedback from the instructor than distance learning systems are able to provide. Schools need to target appropriate student populations for distance learning projects if they expect to achieve success. Teachers play a major role in assuring that satellite classes operate smoothly. Texas must carefully design the qualifications it expects of both the broadcasting teachers and the classroom monitors. Also, the state should evaluate programs to discover which type of formats for delivery are most effective, and identify aspects that can create problems.

Specific concerns that Texas must reconcile as it adopts distance learning programs include state restrictions on teacher certification, classroom size and textbook requirements, and curriculum guidelines. Satellite instruction can enhance education in Texas, provided that stringent guidelines do not create obstacles. Future policies must be flexible to the changes that technologies create. Given the unique nature of distance learning's instructional delivery, Texas may need to make accommodations in its regulations.

Texas should encourage and assist school districts willing to try out new ways of restructuring school environments through the use of educational technology. In addition, states should cooperate with one another to create consortiums and other technical assistance arrangements to save time and resources (1986, pp. 132-133). Texas should work closely with states such as Missouri, which has developed its own state-wide satellite network, and Minnesota, which has pioneered its live two-way video and audio project. Close contact with other states, as well as a willingness to experiment with other states' successes, will ensure that Texas is providing the best education via innovative technologies.

TEACHER PREPARATION

Wide agreement has been reported regarding the effects on teachers due to the uses of new technology in the classroom. For example, the role of the teacher will change, but less agreement was found on the specific nature and extent of the changes. It is impossible to state the effects of technology on teachers due both to uncertainties regarding broad trends affecting the teaching profession and uncertainties regarding technological development (including issues of societal acceptance). The degree of autonomy possessed by teachers will be a major influence on the successful adoption and implementation of technology in the schools. Recent progress in educational technology poses enormous implications for the delivery of schooling. A broad array of scenarios are possible, depending on the pace of technological advancement and the extent of adoption.

The current wave of educational reform has worked both for and against the concept of teacher autonomy. Several recent proposals have recommended decentralizing the administrative structure of schools in order to restore the freedom of teachers to make important decisions regarding curriculum and teaching methods. On the other hand, many recent reforms have emphasized accountability at the expense of autonomy, mandating to teachers the precise content of courses and the methods to be used in instruction. The accountability reforms usually are enforced through elaborate appraisal instruments that minutely specify desired teacher behaviors. A great deal will depend on how the technologies are to be implemented. There are two extreme approaches to implementing the new technologies: the technologies can be mandated from the top down or initiated by the teachers themselves. It is probably too early in the adoption process to centralize decisionmaking regarding technology. Instead, creativity and innovation are called for -- which are best generated through teacher-to-teacher contact. Efforts to impose technology over the objections of teachers will fail. Nevertheless, simply waiting for all individual teachers to embrace technology on their own is not a viable option. The educational system is in need of bold interventions, and failure to consider technology-intensive alternatives to traditional education could impose large social costs, in terms of foregone opportunities for meaningful change. An array of alternatives are possible between the extremes -- for example, hardware or software could be centrally purchased and made available as optional resources for the teachers' use. Teachers then could be provided with monetary or other incentives to use the technologies.

Teachers in the future will need to possess all the skills currently required by their positions in addition to the new skills made necessary by technology. Possible new skill needed include incorporating technologies into the curriculum, operating the technologies as tools for instruction and administration, diagnosing student learning problems, individualizing instruction, managing the new classroom, and teaching high-order skills such as problem solving. Future teaching staffs may divide into specialties, such as lecturers, teacher-programmers, long-distance teachers of specific subject matter, or system monitors whose role would be to free the master teacher for administration and long-range planning. Other outcomes may include greater use of team teaching and interdisciplinary courses.

The quality of teacher training at both the preservice and in-service levels will be pivotal in determining the success or failure of the new technologies in education. Many states have recently established requirements for technology training of preservice teachers; however, little data exist to show whether existing training is effective in promoting greater or more effective use of technology in the classroom. In-service training in technology is available from numerous sources, including colleges of education, school districts, professional organizations, and the private sector. Major concerns exist regarding the need for measures of training effectiveness and follow-up training. Perhaps the most attractive approach is to encourage peer training among teachers. One proposal would have two teachers from each school receive intensive training on an ongoing basis; the teachers then would act as resources for the rest of the faculty.

Standards for teachers in Texas have undergone radical changes in the past decade, most recently in 1987 with the passage of Senate Bill 994, which eliminated the undergraduate degree in education, limited the number of education courses to 18 credit hours, and provided for a supervised initial year of teaching. For a while it appeared that the reduced number of hours allowed in education threatened the survival of the information processing courses required for teacher certification, but in fact the requirements have been retained. Nevertheless, the scope of the legislation is profound and not all of its implications are currently well understood.

Basically, the components are in place for Texas to move forward in promoting technology for educational use. Despite the potential benefits of the technologies and their relatively recent (if incomplete) diffusion through the Texas schools, it is not clear that agreement has been reached regarding the best uses of the technologies. A significant barrier is institutional in nature; namely, the absence of systematic models for school systems to follow in determining their educational needs, in evaluating the effectiveness of the technologies in meeting those needs, in incorporating the technologies into the curricula, and in training teachers to use the technologies effectively. Also absent are incentives for individual teachers to assume the additional burden of incorporating technology into the curricula.

Pockets of innovation exist in certain Texas schools; one of the state's many responsibilities is to identify the key ingredients of those programs and find ways to replicate these successes elsewhere.

MANAGING AND FINANCING THE IMPLEMENTATION OF THE NEW TECHNOLOGIES IN TEXAS

New educational technologies hold great promise for improving school and classroom management, promoting individualized student learning, increasing the speed of mastery, creating greater interest in subject matter, and preparing students for the use of information technologies in their work lives.

The design of a technology program and its method of finance depends on the goals the state wants to achieve. The Texas Education Agency's *Long Range Plan for Technology* lists several justifications for the increased use of technology in public schools. These include responding to social and economic challenges in the state and nation, fulfilling legislative mandates, achieving the mission of quality, equity, and accountability in public schools, and reaching a vision of the future (1988, p. 9-31). The plan enumerates a variety of ways in which technology can fulfill these goals, including aiding at risk populations, increasing basic skills attainment, motivating students, developing high-order thinking skills, changing the curriculum, delivering the curriculum, aiding students with special needs, easing teacher shortages, improving the management of education, and containing costs. These include a wide range of aims, the achievement of which will require several types of programs.

Microcomputers and telecommunications equipment and training costs will likely to be higher than for more traditional classroom approaches -- at least at first. In addition, there are research and development costs.

Options for financing include seeking grants and contributions from the private sector, using short-term bond financing through the Capital Acquisition Program operated by the Texas School Services Foundation, making adjustments to the Foundation School Program, using the earnings or principal of the Permanent School Fund, using the textbook fund to purchase software, and establishing a special Innovation Fund. The advantages and disadvantages of each of these approaches are reviewed.

Chapter 1. Introduction

BACKGROUND

The release of *A Nation at Risk* in 1983 touched off a nationwide debate over the crisis in America's education system. The study crystallized the challenges our schools will be facing in the twenty-first century: reversing the trend in basic skills deficiencies and educating a workforce to meet the demands of an increasingly competitive world economy. Today, it is abundantly clear that as a nation America must invest heavily in education and human resources development if we are to compete effectively in international markets. The same holds true for Texas, which is struggling to diversify its economy, attract new industry, and adjust to dramatic demographic shifts.

The role of technology in meeting this challenge can be significant. First, many believe that technology can provide a cost-effective means of delivering an array of educational services tailored to the educational needs of rural schools as well as students who are handicapped, disadvantaged, or otherwise at risk. Second, educational technology is seen as a tool to accelerate learning, making lessons more effective, interesting, and accessible. Finally, knowledge of the technology itself is imperative in a world where technology is a major and rapidly changing force in the world economy.

Texas has joined the other 49 states in adopting educational reform programs. Since the 1981 act that mandated statewide implementation of a "well-balanced curriculum" built upon a common core of essential elements, Texas has developed comprehensive, long-range plans to improve administrative efficiency and instructional delivery through the appropriate use of technology.

Much of the literature on educational technology either implicitly or explicitly defines technology as computer hardware or software. Slightly broader definitions include references to "electronic systems such as television, radio, computers, and other emerging state-of-the-art equipment, used as part of instructional devices available for classroom instruction" (California Education Code, 1987, p. 4). The Texas Advisory Committee on the Long-Range Plan for Technology refers to the state's current educational technology as computer hardware and software, interactive videodisc, distance learning systems (including cable television, microwave television, delayed-video tape, and the telephone, and telecommunications systems). While these definitions are accurate, they are incomplete. They limit one's vision of the potential of educational technology to that of tasks that can be performed by equipment.

Ray Marshall in volume 1 of this series, entitled *Economics of Education*, offered a more comprehensive definition:

> Technology really means the way to do things, or more precisely, the use of knowledge, tools, and skills to solve practical problems and extend human capabilities.... In a fundamental sense, technology is ideas and knowledge embodied in people, processes, products, management systems, organizational forms, and structures as well as machinery.... It is a serious intellectual mistake to view technology as a noun (physical thing) instead of as a verb (process) (Lyndon B. Johnson School of Public Affairs, 1988, pp. 6-9).

While Marshall's definition may be less tangible than the first two, it forces us to adopt a more holistic approach to incorporating technology into the schools. Technology is both the systems and the strategies behind the systems.

Can Technology Help Texas Public Schools? To most observers, the answer to the question posed in the title of this report is an obvious and emphatic "yes!" Clearly technology has a favorable image in American society, given its association with progress and a better future. Yet the matter is not as simple as that. When most people think of technology, the image of a computer comes to mind. Merely installing computers in classrooms across Texas will not improve education without well-trained teachers, effective planning regarding how these technological tools will be used, high-quality software, and reliable system maintenance. Computers are not self-implementing.

More important, instructional technology needs to be better integrated with the educational process. We need to better understand the teaching and learning processes. We also need to focus on the learning system as a whole and the incentives for learners, teachers, and administrators. Equipment such as computers, software, video cameras, and satellite dishes are no more than tools. One does not teach a man to be a carpenter simply by handing him a hammer and a saw. Attention needs to be devoted to training in how to use the tools. At this point, the subject becomes a little more complex. Reasonable people differ on issues of, for example, how to use computers in the instructional process.

An enduring problem is that educators and technologists/engineers live in different worlds and the educational software developed often is driven by the potential of the technological tools rather than the needs of the learner and teacher. Yet teachers and learners are the central figures in the educational process.

We need to integrate the use of technological tools with what we know about learning. It is clear that students are not just receptacles into which knowledge is poured by teachers. Rather, learners actively construct their own understanding of subject matter in relation to what they already know. Learning is best characterized not as a process of assimilating knowledge but one of constructing it. A simple transmission view of learning does not work, since students bring their own preconceived ideas to the learning task, and they must work at building new conceptual understandings, and abandon or transform old preconceptions.

Second, the acquisition of higher order thinking skills and in-depth knowledge in a domain are integrally related. Both are developed through practice that helps students to use their knowledge and make it more usable. Knowledge becomes flexible when students actively apply it. Learning-by-doing is essential. Unfortunately, much school-based knowledge remains inert and unusable since factual and algorithmic knowledge are emphasized for the purpose of remembering for a test. Nor do lectures, which comprise the bulk of time spent in Texas classrooms, foster active learning. Too much emphasis has been placed on short-term memory rather than thinking.

Third, effective learning is concentrated in larger tasks in the classroom that give learning meaning and help to motivate learners, and it is closely associated with motivation and self-esteem. Ideally, learning begins with questions asked by the learners themselves. Learning becomes more meaningful if it is part of a discovery process.

The need for change in teaching and learning practices is evidenced by the fact that many students become mentally disengaged from school as early as the fourth grade and fully one-third of Texas students leave school before completing high school. The solutions to dealing with "at risk" students are not to be found by focusing only on the deficiencies of the student -- but by examining the process of education itself.

ORIGIN OF THE PROJECT

This project was developed in discussions between Ray Marshall and Robert Glover of the Lyndon B. Johnson School of Public Affairs and staff of the Division of Research and Information, Texas Education Agency (TEA) during Summer 1987. The LBJ School planned to offer a Policy Research Project during the 1987-88 academic year entitled Education, Technology, and the Texas Economy, which would examine relationships between the changing Texas and national economies, technology and education. Through the discussions, TEA staff identified several questions which they wished to see addressed as background for the preparation of the state's Long Range Plan for the Use of Technology and other purposes. The questions were divided into three general topics as follows:

I. EDUCATION AS IT AFFECTS TECHNOLOGICAL AND ECONOMIC DEVELOPMENT

1. What is the relationship between levels of competency attainment in public education and the potential for growth and diversification of the Texas economy?

2. What basic and technical skills will be required because of advances in technology?

3. What are the implications of implementing the master plan for vocational education, adopted by the State Board of Education on January 10, 1987?

II. TECHNOLOGY AS IT AFFECTS THE DELIVERY OF EDUCATIONAL SERVICES

4. How can technology be used to improve the efficiency of learning and how can technology be integrated with other learning processes?

5. How can technology and distance learning be used to support adequate programs for small numbers of "special population" students in small schools across Texas? What implications does education-by-telecommunications have for personnel certification, textbook adoption and distribution, class-size requirements, and any other laws and regulations?

6. What are the potential applications of new technology for the delivery of instructional services and for teaching skills?

7. What effects will utilization of advanced technology in classrooms have on the training and skill requirements of instructors?

8. How can computer technology be used to improve the teaching of mathematics in Texas?

III. IMPLICATIONS OF USE OF HIGH TECHNOLOGY FOR FINANCE AND ORGANIZATION

9. What innovative financial arrangements can be made to underwrite the cost of installing, maintaining, and using high technology? What issues do these arrangements raise?

10. What are the economic and other measures that can be used to evaluate the return on investment in high-cost technology?

11. What are the organizational consequences of a statewide technology system for the roles of and relationships among regional education service centers, school districts, campuses, and the state agency?

At the inception of the project in Fall 1987, Ray Marshall developed a background paper, entitled *Economics of Education*, which primarily addressed questions 1 and 2, although it touched on a wide range of topics related to several of the other questions. This paper was published as volume 1 of the project. Students working with the project either individually or in teams selected one of the TEA questions and conducted research on it throughout the year. The results of selected papers are contained in this volume and in volume 3, entitled *Vocational Preparation*.

PREMISES

As a starting point, this report accepts as premises several ideas argued in *Economics of Education*, volume 1 of this project report.

1. Technology is not merely equipment; equipment is only embodied knowledge. It is important to understand technology, in its broad definition, even when most attention is given to the new technological tools, such as computers and telecommunications devices.

2. Just as there is no one best way to learn, there is no one best way to use technological tools in teaching. The use of computers and telecommunications for education is in its infancy. In this early period of ferment, flexibility, experimentation, and room for innovation are required.

3. The use of technological tools does not replace teachers. Rather it *extends* their capabilities.

4. The incorporation of new technology requires attention to understanding of its *systemic* implications.

5. Good decentralization requires good centralization. Education systems are neither completely centralized or completely decentralized. The new technologies will lead to greater decentralization and to the empowerment of teachers and students by putting more and better information in their hands. However, effective implementation of the new technologies requires effective planning and action on the part of state authorities.

6. No matter which side is correct in the debate over whether technological change increases the skill requirements of jobs or deskills jobs, individuals who are highly skilled will do better on average both in life and in the labor market. Likewise, the society with higher skilled individuals will be more competitive in the world marketplace.

THE POTENTIAL OF TECHNOLOGY

Technology has powerful potential to serve the educational process, but most experts agree that its potential has barely been tapped to date. The process of technological diffusion in education is a slow one; the lag from basic research to implementation in the classroom has been as lengthy as 20 years (U.S. Congress, Office of Technology Assessment, 1988, p. 151.).

While the 64 K machine typically found in today's schools can run some good educational and application software, developments recently achieved or predicted for the relatively near future are nothing short of astonishing. Within the next decade -- that is, by the end of this century -- video, audio, and electronic technologies will merge. In fact, we are already beginning to witness the development of integrated multimedia materials.

Roy Amara, president of the Institute for the Future, points out that the technologies of the computer and telecommunications are converging. He predicts that soon telecommunications equipment will be available at a reasonable price so that schools can afford to carry simultaneously a full range of media, including two-way picture, voice or other audio, text, and data (Amara, 1988). Indeed, all knowledge -- including data, text, voice, and still and moving pictures -- can now be converted into digital form, which makes it subject to computerization and electronic storage.

While it is easy to become excited about the technological possibilities in education, there is also a danger of acting too early, thereby wasting monies. Historically, the cost curves in electronics have been high initially but dropped steeply. Due to miniaturization and other factors, electronic products are one of the few sectors of our economy experiencing deflation. The expenses of research and development for hardware and software products are high; but these costs drop sharply as they become spread over many units. Although Texas educators must take care lest they spend too much needlessly too early, Texas should be positioned to take advantage of technology as soon as prices of high-quality instructional technology decline to reasonable levels.

Alternative Visions of the Future

Many of the effects of educational technology will depend on how the technologies develop and are implemented. Two extreme alternative visions were recently presented by a Texas futurist (Dede, 1987, pp. 1-9).

In scenario I, research in artificial intelligence progresses very rapidly between now and the turn of the century, thus making machine-based intelligent tutors and coaches feasible.

> . . . usage of intelligent systems and cognition enhancers could shift the focus of instruction to individual mastery of procedural knowledge and higher order cognitive skills; facilitate the participation of parents, community, workplace, and media in education; increase the cost-effectiveness of instruction; enable schools to be more responsive to the changing needs of society; and improve the working conditions and status of teachers (Dede, 1987, p. 3).

In this scenario, the thinking skills of the human instructor would become increasingly important. The curriculum might become divided into two parts: training and education. Training would cover material for which there are only a limited number of possible "right" answers, and machine-based tutors could readily perform this function. Education, on the other hand, would encompass questions for which there are many possible right answers, such as human relations, creative writing, citizenship, or decision-making.

> Such a pedagogical paradigm would shift the attributes and preparation needed for teaching toward higher-order intellectual skills, improve working conditions by removing the monotony of rote training from the teacher's role, and make instruction a better paid and more respected profession (Dede, 1987, p. 5).

The best case scenario implies:

1. Technological advancement -- computers will be able to match instruction with the student's unique learning style. Students will all have computers which are linked to the teacher's computer, thus allowing for instant feedback to students. Teachers will monitor individual student progress continuously, and most administrative tasks, such as attendance, grading, testing, and special reports for state and federal programs, will be carried out by the computer

2. Changes in instructional models -- the "new" classroom will be designed around the means of instructional delivery. There will be workstations for individual tutoring and drill and practice exercises, and small-group areas using simulations and other technologies which encourage students to help each other and foster the ability to work in a team atmosphere.

3. Changes in instructional goals -- instead of focusing on a discrete body of facts and skills, an approach based on the linkage of facts and experiences with abstract concepts will emerge. The emphasis will be on developing an integrated body of knowledge, including the ability to monitor one's own level of understanding, recognize gaps in one's knowledge, develop learning strategies to close the gaps, and create and test one's own hypotheses (Urban Institute, 1987, pp. 1-4).

4. Changes in the teacher's role -- "Teachers of the future will have many more tools to do an even better job and their productivity will increase drastically" (Urban Institute, Deringer, 1987, p. 1). The ideal teacher will be a "coach" or enabler of student achievement, possessing creativity and flexibility, a thorough knowledge of the subject matter, and the skills required to guide a room full of students working at different levels and using different media. Teachers no longer will be interchangeable. A hierarchy will be established with master teachers gaining both respect from society and pay that is competitive with other intellectually demanding jobs. Teachers who are not as competent or motivated will work as tutors or planners. Others will specialize in developing software, maintaining and coordinating hardware, and teaching other instructors new applications.

In Scenario II, inadequate development and implementation of the information technologies, as a result of failures in any of the assumptions required for the first scenario, lead to serious negative consequences for American society. The failures may be due to many causes: insufficient funding, lack of skilled human resources, or a failure to implement research initiatives. The greatest potential failure, though, might be outright rejection of the technology-intensive alternative by schools, universities, parents, or communities, in the form of inertia, self-interest, and resistance to change. The current lack of agreement in America about proper goals, methods, responsibilities, and funding for public education makes this second scenario somewhat more plausible than the first (Dede, 1987, p. 8).

Changing the Technology of Education: Developments Underway in Texas

Several efforts to apply technology to education already are underway. Although many of these efforts were begun on an ad hoc basis, they will be coordinated under the newly approved *Long Range Plan for Technology* and the *Long Range Plan for Information Systems* adopted by the Texas State Board of Education in December 1988 (TEA, 1988; TEA,1989). Texas state law contains several provisions that deal with educational technology; specifically, various legislation

1. requires financial assistance for computer services offered by regional education service centers [Texas Education Code Section 33 (b) (1)]
2. requires the establishment of a Software Advisory Committee to recommend a process for distributing information about quality software. (chapter 14 of the Texas Education Code)
3. requires the development and adoption of a statewide Long Range Plan for Technology (chapter 14 of the Texas Education Code)
4. authorizes preparation of a Long-Range Plan for Information Systems (Vernon's Texas Civil Statutes 4413 (32h)
5. requires that all students in Texas take at least a one-semester course in computer literacy in seventh or eighth grade, beginning in the 1985-86 school year. The required course includes specific applications, awareness, programming, the history of computers, and the ethics of computer use. Since Fall 1987, all districts have been required to teach computer competencies, including keyboarding, in elementary school.

Education students in Texas are required to take a computer course or demonstrate proficiency using computers in instruction. The state's long-term strategy for both preservice and in-service instruction involves moving delivery of training for technology to universities and regional centers. The Texas Education Agency (TEA) Division of Educational Technology trains regional service center staff who, in turn, are responsible for training local district staff in technology-related skills. Division staff also consult with service centers and districts, providing technical and curriculum assistance and guidance in long-range planning

Between 1985 and 1987, TEA conducted an electronic communications pilot program with 14 school districts to test the effectiveness of sending information electronically. The pilot project, entitled "The Electric Pages," proved successful and the system was modified and adopted statewide as TEA-NET. By the end of the experiment, over 520 districts had access to the network (270 of them new users). TEA distributed announcements, publications, and memos to administrators and teachers over the network. The present version of the electronic network, TEA-NET, includes participation by a large network of state associations and agencies related to education.

Beginning in 1986-87, Texas used its federal Chapter 2 discretionary funds to finance pilot programs in ten school districts to study the use of technology for basic skills instruction. During 1987-88, eight additional projects were funded. These projects provided districts with the opportunity to develop knowledge and experience with computer hardware and software. Although the results of the projects were disseminated to other districts, none of the projects has evolved into statewide recommendations.

Beginning in the fall of 1988, each local school district was required to develop and implement a plan for the use of technology, with an emphasis on introducing keyboarding skills at the elementary level. By the fall of 1989, campuses must begin to put technology plans together. No state funds were appropriated to pay for this planning, but the TEA Office of Technology provides technical assistance to help districts and campuses comply. TEA staff hold workshops to assist districts in developing their plans. The contents of the plans are left entirely to the discretion of the districts. TEA is mainly concerned that the districts undertake the planning process; it will not review and approve district plans.

PLAN OF THIS REPORT

The following three chapters review various specific applications of technological tools to education. This section begins with a discussion of the application of technology to teaching basic skills, in part because that is the subject in which computer-assisted instruction (CAI) started. It then discusses two innovative systems -- the Comprehensive Competencies Program (CCP) and the Writing to Read Program -- which clearly illustrate that technology means more than computer equipment. Although both programs use computers as one of a series of learning stations, CCP and Writing to Read are *learning systems* that radically restructure the delivery of instruction in a systematic way. Chapter 3 discusses the use of computers in teaching mathematics, especially higher mathematics. From computers, we move to telecommunications and other devices, with Chapter 4 on distance learning. Chapter 5 deals with the implications of technological change on teacher preparation. Chapter 6 discusses how selected other states organize and finance educational technology. The final chapter explores options to finance the implementation of educational technology in Texas.

Chapter 2. Using Technology to Teach Basic Skills

This chapter focuses on ways that technology can assist in teaching basic skills, especially to meet the needs of students at risk of school failure. Teaching basic skills is an appropriate place to begin, for most of the early efforts to use the computer in education were directed toward computer-assisted instruction (CAI) in basic skills, especially through drill and practice exercises. A considerable literature evaluating the use of computers in basic skills instruction has developed over time. This chapter reviews some of the available literature on the topic.

The chapter then goes on to discuss two innovations, the Comprehensive Competencies Program (CCP) available from U.S. BASICS and Writing to Read available from the IBM Corporation, which clearly illustrate that using technology effectively in education involves more than simply installing computers in classrooms. Both programs are systems for managing and delivering instruction in a nontraditional way. Although both programs are strongly identified with computer-based instruction, each uses the computer only as one of a series of workstations. The Comprehensive Competencies Program (CCP) aims to accelerate learning in basic skills by disadvantaged individuals through a structured system of individualized, competency-based instruction. Writing to Read was developed to teach kindergartners and first graders to read and write, building on the oral vocabulary which children bring to school.

THE IMPORTANCE OF BASIC SKILLS

In today's changing economy, it is essential that all individuals possess basic skills (the ability to read, write, compute, and communicate effectively). No longer able to rely primarily on natural resources, Texas must develop its human resources to diversify its economy and to prosper. Yet at this crucial time Texas faces high rates of functional illiteracy. The [Texas] Task Force on Literacy of the State Job Training Coordinating Council estimated that 20 percent of the Texas population was functionally illiterate in 1987 (1987, p. 2). If this us true, 20 percent of the state's population cannot perform such elementary tasks as reading maps, bus schedules, or simple instructions at work. Lack of proper reading ability results in loss of time and productivity. As the nature of jobs becomes more sophisticated, productivity will be even more greatly affected (Eurich, 1985, p. 60).

The Task Force attributed the causes of functional illiteracy to the state's high dropout rate, to ineffective schooling, to societal attitudes, and to lack of support for education in the home (1987, p. 2). Many social and economic pathologies including poverty, bearing children out of wedlock, welfare dependency, and crime are highly correlated with lack of basic skills (Berlin and Sum, 1988, p. 29).

A study conducted by the Intercultural Development Research Association (IDRA) estimated that as of the 1985-86 school year, fully 33 percent of all students left school before completing high school in Texas. Attrition rates differed noticeably by racial/ethnic groups: 27 percent for Anglos, 34 percent for blacks, and 45 percent for Hispanics (IDRA, 1986 p. i).

Given the demographic trends Texas faces, the differentials in these dropout statistics are especially worrisome. Available data indicate that minority populations currently represent 35 percent of the Texas population base and 46 percent of its youth. Texas has the third highest black population, and the second highest Hispanic population in the country, yet ranked 42nd in high school graduates (Hodgkinson, 1987, p. 2). By the end of the century, minority groups are expected to comprise over 40 percent of the population of Texas, and school enrollment will be over 50 percent minority (Hodgkinson, 1987, p. 11). Since minority students traditionally have experienced higher rates of school failure than their Anglo counterparts, one can easily project an increase in the overall dropout rates without some intervention.

The IDRA study revealed that despite high rates of noncompletion, little attention was paid to the dropout issue. No consistent formula was used by Texas school districts to calculate the dropout rate. Only about 12 percent of Texas school districts reported having a dropout program. Further, of the programs that existed, only a handful had been evaluated (IDRA, 1986, pp. i-ii).

The findings of the IDRA study prompted passage of House Bill 1010 in the 70th regular session of the Texas Legislature in 1987, which required the Texas Education Agency to collect data on student dropouts using a consistent definition specified in the law. The TEA is complying with this mandate by adding data elements to the computerized Public Education Information Management System (PEIMS). PEIMS will provide improved methods of collection of student data, and uniform compilation and reporting of student information.

Identifying Students At Risk

The students at risk traditionally have been more difficult to instruct than their peers. Complicated social and economic forces may cause their problems, but the problems tend to have a single result: lowered expectations for these children, which compound their likelihood of failing in school (Agency for Instructional Technology, 1987, p. 37). Children at risk tend to have low self-esteem, which manifests itself in a belief that they are powerless to control their own destiny--a factor that complicates intervention with the at risk student (Agency for Instructional Technology, 1987, p. 57).

Given the increasing concern for the at risk student in Texas, What is the potential of the new educational technological tools to improve their basic skills and educational attainment? David W. Hornbeck, superintendent of Maryland schools, summarized the value of using computers to assist in educating these students, pointing out:

> The computer motivates; it is nonjudgmental; it will inform a student of success or failure without saying by word or deed that he or she is good or bad. The computer individuates learning, permitting mastery at the student's own pace. In most instances, the learner has far more autonomy than in many other classroom, teacher-directed settings. The computer gives immediate feedback. And good software gives the computer the added potential of being remarkably imaginative. Such generic qualities cut across computer technology, allowing the learner at least the impression, and often the reality, of being in charge. This is the quality missing in the lives of many students, especially those who are at risk, due to an environmental, physical, mental or language disability " (Agency for Instructional Technology, 1987, p.61).

Research and media attention has prompted policymakers to attempt to identify factors which lead to student attrition. Andrew Hahn and Jacqueline Danzberger, researchers at Brandeis University who have devoted considerable time to studying the problems of at risk students, have catalogued ten conditions to identify students at risk of school failure. These include falling behind in grade level and being placed with younger classmates, poor academic performance, dislike of school, high rates of detention and suspension, becoming pregnant, receiving welfare, members of single-parent households, becoming attracted to drop out of school to work or join the military service, having undiagnosed learning disabilities and emotional problems, or having language difficulties (Hahn and Danzberger, 1987 pp. 259-269).

Technological tools can assist in the amelioration of several of these problems. It can help identify students at risk. Systems such as PEIMS may be useful for generating data about this population. Computer-aided instructional programs can assist in the diagnosis and remediation of learning disabilities. The student may also begin to enjoy school more if he/she receives self-paced computer instruction on an individualized basis. Early intervention and remediation may accelerate learning, help bring the student up to grade level, and avoid problems associated with grade retention and being older than one's classmates.

Of course, since dropping out of school is a multi-faceted problem, resolving it calls for a strategy that has several components. Hahn and Danzberger identified elements necessary for effective dropout prevention programs at the high school level. They conclude that to succeed, dropout prevention for older youths requires a cohesive, integrated effort that combines at least the following components: mentorships and intensive, sustained counseling for troubled youngsters; an array of social services, including health care, family planning education, and infant care facilities for adolescent mothers; concentrated remediation using individualized instruction and competency-based curricula; an effective school/business collaboration that provides ongoing access to the mainstream economy; improved incentives, including financial rewards, for students to complete high school; access to year-round education and alternative schools; heightened accountability for dropout rates at all levels of the public education system; and the involvement of parents and community organizations in dropout prevention (1987, p.261).

Computerized information systems will help alleviate some of the administrative burdens associated with tracking students at risk. Data generated from programs such as PEIMS, over time, will generate a better data base of students at risk, help refine our knowledge of risk factors, and alert counselors, teachers, and parents. Computers can assist in the remediation of students through computer-based instruction. However, it is clear that merely installing computers in the schools will not be enough to solve the problems of school dropouts. Texas school districts must develop strategies that integrate basic skills training, adequate counseling, and small group instruction. Students at risk of school failure need personal motivation, encouragement and remediation in basic skills. A comprehensive program which combines these components is essential to a successful dropout prevention /intervention program.

Progress is certainly attainable. For example, a three-year intervention program in Ossining, New York, was reported to decrease the dropout rate, the absence rate, and the suspension rate (IDRA, 1986, pp. 40-41). The program provided students with alternative academic programs combined with teacher and staff training in classroom management, discipline, and instructional techniques. Families were also counseled and trained to deal with the special needs of the at risk student.

Early intervention in the schooling process will lead to improved student retention. Other important dropout prevention program components are high expectations of students and small group instruction (IDRA, 1986, p. 41). Basic skills instruction is an important component in any effective dropout prevention program.

THE EFFECTIVENESS OF COMPUTER-BASED INSTRUCTION ON IMPROVING BASIC SKILLS

For almost 30 years, researchers have explored the effects that computer-assisted instruction can have on student achievement in basic skills. One way of synthesizing these studies is to conduct a meta-analysis, which is a "statistical analysis of a large collection of results from individual studies for the purpose of integrating the results" (Kulik, 1983b, p. 4). A recent meta-analyses of 43 studies examined the efficiency of computer based programs in grades 7 through 12. The results showed that "CBI [Computer Based Instruction] programs produce, on average, small but significant improvements in students' scores on achievement tests" (Samson, et al, 1986, p. 312). The study also found that "higher mean effects were obtained in inner-city schools, in studies with lower socioeconomic level students, with black students, and with students of below and above average achievement" (Samson et al, 1986, p. 316). Other findings indicate that larger effects on standardized tests were obtained in programs involving drill and practice and tutorial-type activities than with programs involving problem solving. Niemiec et al. evaluated the effects of computer-based instruction in elementary schools (grades K-8) by conducting another meta-analysis. They determined that CBI is much more effective in the primary grades, concluding

> In the typology of the computer's use in education, drill produces the highest effect sizes (0.47). In the elementary school, drill and practice usually involve rote memory, flash card type tasks. Gains for the tutorial are more modest. In the tutorial, the computer presents concepts in addition to reinforcing them. Using the computer as a problem solver produces small effects (0.12) (1987, pp. 97-98).

Of course, this finding may be more a criticism of the quality of software available for problem solving than a comment on the potential of the computer to help teach problem-solving.

Ragosta, Holland, and Jamison explored the effectiveness of utilizing CAI for compensatory education. The study took place over a period of four years in the Los Angeles Unified School District . It produced the following findings: with only ten minutes per day of mathematics CAI, students made significant gains in their computation skills compared to control students; with twenty minutes of mathematics CAI, students doubled gains in computational skills. During a second and third year of mathematics CAI, students increased their gains significantly. In reading and language skills, smaller but consistently positive results were obtained in the first year with ten minutes of CAI daily. Reading and language skills were maintained, but not increased, with additional years of CAI (1982, p. 78).

Henry Levin of Stanford University's School of Education, in a study assessing the use of computer-assisted instruction in addressing the needs of disadvantaged students, concluded that:

> Computer Assisted Instruction (CAI) may be an effective strategy for practicing basic skills and for learning other subjects. Results from careful evaluations suggest that it is possible for disadvantaged students at the elementary level to increase reading achievement by about a quarter of a year beyond what would be accomplished in regular instruction by taking 10 minute daily sessions in drill and practice during the school year. Gains in mathematics are about half this amount. These results appear to be attainable at a cost of only about $120 per student per year for each subject, a small fraction of the $3,000 average that is presently allocated to each student in the nation. In addition, there is a large amount of computer software and inexpensive computers (in the $100 range) designed for home entertainment and education that might be harnessed by school districts to assist disadvantaged students in their homes (Levin, 1986, p. 27).

Several school districts in Texas have utilized computer-based instruction for basic skills with promising --although not definitive -- results. The Stafford Elementary School in the Italy Independent School District has integrated the IBM Writing to Read program at the kindergarten and first grade levels of instruction. Their evaluation of the program was positive; they reported rapid increases in language skills (especially by the low achievers); increased self-esteem, and the development of strong motivation among the children (Roland, 1987).

Success also was reported by the Fort Worth Independent School District, which utilized CAI programs for drill and practice in language, math, and/or reading for educationally disadvantaged students in seven Chapter 1 schools. Results on the Iowa Tests of Basic Skills (ITBS) showed outstanding achievement gains in all three skill areas. The gains for math ranged from one year to one year and eight months, for reading gains from one year and one month to one year and two months, and for language between one year and one month to two years and two months. Use of CAI resulted, for the first time, in reducing the achievement gap between educationally disadvantaged students and their peers attending Fort Worth schools (Powell, 1983, p. 103).

The Cypress-Fairbanks Independent School District implemented a computer-based program for reading and language arts using Apple IIe computers. Approximately 80 students had access to the computer centers two hours per day. Results indicated little difference in tested achievement between the group using the computers and those who did not. Among the group with computers, 80 percent mastered the reading objectives on the teams test, compared with 77 percent of the comparison population (Cypress/Fairbanks ISD, n.d., p. 3). Data on higher order thinking/ interpretive skills suggested that the computer activities, which integrated writing and reading, benefited students in both the development of basic reading skills and higher order thinking skills (Cypress/Fairbanks ISD, n.d., chapter 2, p. 4).

The Pittman-Intermediate School of the Raymondville Independent School District established a computer laboratory, using Apple IIe computers. The school implemented a computer-based instruction system for teaching basic skills to 700 students in grades 2 through 5. While data are not yet available to determine the impact of the program, the students were receptive to the program and excited about using the computers (Perez, 1987).

Students who are motivated and enthusiastic about learning may perform better in school, have a more positive self image, and try harder to increase achievement. Motivation is certainly significant for the special population students in Texas schools. Several school districts in Texas have explored the possibilities of successful integration of technology-based instruction. Utilizing technological tools for basic skills attainment may be an effective and cost-efficient way for at risk students to increase attainment and close achievement gaps.

Voices of Caution on Computer-Based Education

The previous section described the positive attributes of computer-based instruction in basic skills. Some educators, however, caution that those in the educational establishment who are prone to look upon computer-based instruction as a quick fix to perceived deficiencies in teaching and learning are likely to be disappointed.

Research conducted by Toby Tetenbaum and Thomas Mulkeen of Fordham University explored the limits of computers in education. They contend that educational institutions have "embraced the new technologies as a panacea for their ills" and that "as traditionally conservative institutions, they have acquired the technologies faster than they can learn how, when, or where to use them" (1984, p. 2). Tetenbaum and Mulkeen expressed special concerns about the exclusive use of computers for drill and practice:

> This emphasis on drill-and-practice reinforces the use of computers as transmitters of predefined content and places the student in the role of receiver or respondent. While computers have the potential to create simulations that can teach high level thinking and problem solving, most software is aimed at teaching skills or draws almost exclusively on recall rather than developing higher order thinking (1984, p.11).

Tetenbaum and Mulkeen conclude with a warning about overselling the computer as an educational tool:

> History's message seems to suggest that enthusiasm and hype are insufficient to sustain a medium of instruction. In fact, promises not met and expectations unfulfilled often produce strong negative effects. It is already becoming clear that microcomputers have been oversold too early, creating a mounting backlash and opposition to the campaign for computer literacy in schools" (1984, p.15).

Technological tools alone cannot be expected to enhance learning. It may be more useful to think of technology as a verb which describes a process, rather than a noun which refers to a static physical object (Holloway, 1984, p. 2). Successful integration of computer-based instruction into the curricula will entail specific prerequisites. First, planning must be conducted based on objective research investigating all aspects of instruction enhanced by the computer. In this regard, failures may be as instructive as successes. Secondly, implementation must place training of teachers and staff as a top priority. Without teacher support, no technological tool will be effective in accelerating the learning process. Finally, technology should not be looked upon as an end in itself, but as a vehicle to enhance learning.

INNOVATIVE LEARNING SYSTEMS THAT MAKE USE COMPUTER-BASED INSTRUCTION

The Comprehensive Competencies Program (CCP)

Several curricula and program models have been implemented with the specific objective of improving the skills of disadvantaged or educationally deficient youth. One of the more promising approaches is a program called the Comprehensive Competencies Program (CCP), developed by the Remediation and Training Institute of Alexandria, Virginia, and operated by its subsidiary, U.S. BASICS, under funding from the Ford Foundation. CCP is a system for managing and delivering competency-based instruction on an individualized, self-paced basis, using a variety of media. The CCP distills lessons learned from several billion dollars spent by the federal government and foundations over the past 25 years under the Economic Opportunity Act of 1984 (EOA), the Manpower Development and Training Act of 1962 (MDTA), the Comprehensive Employment and Training Act of 1973 (CETA), the Youth Employment Demonstration Project Act of 1977 (YEDPA), and the Job Training Partnership Act of 1982 (JTPA). Robert Taggart, who originated the CCP, served as director of the Office of Youth Programs in the U.S. Department of Labor and personally oversaw the Job Corps and a wide variety of demonstrations and experimental pilot projects for youth between 1977 and 1980.

CCP attempts to accelerate learning for disadvantaged individuals. The results have been impressive. Taking account of all learners in CCP from 1984 through the first quarter of 1987, the average grade gain achieved was 1.0 grade level in reading and 1.4 grade levels for 27 hours of instructional time on task in reading and 27 hours in math (Taggart et al., 1987b, p.24). The most recent available information on grade level gains from U.S. BASICS shows that these gains have been maintained as the system expanded to new sites. Information on performance of the system nationwide for the third quarter of 1988 shows a reading gain of 1.0 grade levels for 29 hours of time on task, and 1.2 grade levels gained in math for 30 hours of instruction.

Essentially, the CCP is the academic portion of the Job Corps curriculum in an exportable, replicable format. It has been enhanced by incorporating basic prescriptions from the research on effective schools, organized as a nonprofit franchise on the philosophy that social programming should be operated on business efficiency principles and improved continuously using the results from a built-in evaluation system which provides quarterly feedback on the performance of CCP. For education, perhaps the most revolutionary feature of CCP is that the system offers a practical way of converting classroom management from time-based, lecture-centered, group instruction into a competency-based, individualized, self-paced mode that makes effective use of a variety of instructional media and approaches. In a single classroom, the CCP combines workstations for paper and pencil work, print materials, video tape, audio tape, and computer courseware.

The CCP curriculum covers academic and functional competencies from first grade through twelfth grade, organized in a hierarchical learning sequence and divided into "bite-sized" lessons, each designed to be completed in about two hours. The CCP curriculum covers a range of academic competencies from elementary reading and arithmetic through high school and introductory college-level subjects. It also covers functional life skills or survival skills designed around the Adult Performance Level (APL) assessment devised by The University of Texas at Austin under contract to the U.S. Department of Education in the early 1970s. Beginning with the 1988 edition, U.S. BASICS added a subject strand on English as a Second Language to the CCP curriculum and a Spanish version of all lessons at grade levels 1 through 4. A group of CCP learning centers in Texas has organized a nonprofit coalition called TEXAS BASICS, which has matched, or crosswalked, CCP academic competencies to the Essential Elements for 74 courses in the Texas Public School Curriculum (TEXAS BASICS, 1988).

CCP lesson assignments refer learners to a variety of instructional media, including print, video cassettes, audio cassettes, and computer courseware, as well as experiential learning activities. CCP uses a selection of public domain materials and commercially available instructional materials chosen on the basis of their quality and cost. As of 1989, CCP lessons made use of instructional materials from more than 100 different suppliers.

CCP uses diagnostic mastery tests to assign each learner to instruction of appropriate difficulty in only the subject areas that have not been mastered. The CCP is based on a hierarchical framework of competency objectives, and each learner's progress through this hierarchy is documented by the results on associated mastery tests, machine scored and maintained in a computerized record for each participant as part of the built-in management information system. The computerized systems for managing CCP minimize paperwork and time required for planning and assigning lessons on an individualized basis, as well as providing an efficient mechanism for recordkeeping and reporting. An attractive feature of the CCP for learners is that instruction can be offered on a drop-in basis or scheduled for a few hours a week. The typical learner is in a learning center five days a week for a 2 - 4 hour block of time. Most institutions use CCP in combination with other education, training, and/or work experience.

The CCP builds in prescriptions derived from research on effective schools, including the following principles. Learning basic skills is a step-by-step process best achieved through individualized, self-paced instruction that is competency-based rather than time-based and is more feasible when it can be more flexibly scheduled and sequenced. Learning is facilitated when a variety of instructional materials and media are available and used. Learning is given impetus and direction by frequent feedback on progress and greater accountability for learning efforts and outcomes. Learning is enhanced when learners have a sense of "efficacy," taking responsibility and directing their own learning toward agreed-upon goals. Learning depends on the applied learning time or "time-on-task" during instructional hours. Learning is easier for those who believe that they can learn and is enhanced by instructors, instructional approaches, and instructional settings which provide positive reinforcement. Learning is nurtured in a structured yet supportive environment which deals with personal problems so that they do not intrude on learning. Caring teachers are needed to provide individual attention and assistance. Learning is faster and more directed when integrated with other activities and pursued as a means to other ends (Taggart et al., 1987a, p. 2-6).

CCP is available on a franchised basis exclusively to public and nonprofit organizations that target their services to individuals who have limited education and employment opportunities and who are in need of improved basic skills. The franchise arrangements aim to assure quality control in the use of the system and to provide data for improving CCP. Each franchise site prepares and submits an application, including an annual plan submitted on an Appleworks spreadsheet template for review and approval, signs a franchise agreement, and pays a fee of $1,000 per year that helps cover national administration of the system including servicing, replication, research, and development. Under terms of the franchise agreement, learning centers must agree to document learning through the use of pretests and post-tests; record learner characteristics on a computerized file; require learners to keep track of time spent on task; report quarterly on the system's use by sending to U.S. BASICS a one-page report and a copy of the computerized participant records; assure that learning center staff are training in the CCP; and share information, or network, with other CCP users. In response to the quarterly reports that each learning center sends to U.S. BASICS, it receives the results of an audit conducted on the quality of the learning center's records and a report showing its national ranking in terms of 10 standardized performance indicators. The key point here is that the franchising concept and the built-in research/evaluation features are part of the technology of the CCP.

The CCP is designed to facilitate replication. The system is documented fully in a series of reference manuals and user guides. In addition, a cadre of CCP practitioners have been trained and certified to deliver technical assistance to new learning centers, to train new staff, and to troubleshoot problems.

The CCP is designed to be improved continually. Based on empirical results from the built-in evaluation system and feedback from annual surveys of teachers, learning centers managers, and learners, U.S. BASICS undertakes continuous development and improvements in the system. Introduced in 1984, the CCP has been updated annually so that by January 1989, it was already in its fourth edition.

Perhaps the most attractive feature of CCP is that it is designed for flexibility. Since multiple instructional materials are referenced into CCP lesson assignments, local learning centers can choose virtually whatever configuration of instructional materials, audio-visuals, and computer courseware and corresponding hardware they want to use. Moreover, teachers who do not like the instructional materials in the lesson assignments can supplement or even replace them by changing or "customizing" the computerized CCP lesson assignments. Due to its simple but ingenious architecture, CCP is unlikely to become outmoded by advances in technological tools. For example, as soon as computerized interactive video technology reaches reasonable quality and cost standards, it can be added to the lesson assignments simply as another medium for use by learners.

Developed from 1981 to 1983 and field tested in 1984, by January 1989 the CCP was in use in more than 340 learning centers sponsored by various community-based organizations, schools, colleges, and job training programs across the nation. Texas ranked as the lead CCP state, with more than 60 learning centers.

Limitations and Shortcomings of the CCP

As of 1989, U.S. BASICS' curriculum covered only basic skills in order to give them the priority attention that they deserve. The CCP curriculum is strongest at the third-to-ninth grade levels because that is the range over which the Job Corps curricula is strongest. (The average Job Corps entrant reads at the fifth grade level.) CCP contains instructional materials for use in teaching nonreaders to read; however, in order to use the CCP properly, individuals who cannot read at all often require considerable one-on-one tutorial assistance from a teacher's aide or literacy volunteer. At the upper end of the curriculum, the college preparatory curriculum included only a few materials for overview and review.

The time learners spend in CCP learning centers averages only three or four months. Part of the explanation for the brevity is that JTPA has been the primary source of funding for CCP learning centers. JTPA performance standards tend to drive contractors to offer low-intensive services in order to achieve rapid outcomes. Some critics of CCP have questioned how much entrants who read at or below the seventh grade benefit from raising their reading and math levels by only a grade or two. Clearly many individuals need longer term treatment. The handoff to further education and training in community colleges or other institutions is an important issue.

The CCP relies almost exclusively on programmed instructional materials. While programmed learning offers certain advantages, it also may have shortcomings. For example, while students may learn faster in a programmed learning mode, they may also forget faster as well unless their learning is reinforced.

Because the CCP primarily relies on machine-scored tests, almost all test items are multiple choice questions. While multiple choice questions may be satisfactory for assessing basic skills, they have significant limitations when used to assess higher order thinking skills. Of course, teachers in local sites are free to devise and use their own tests (including essay tests, oral tests, or practical tests) to supplement the tests in the CCP.

Independent assessment of the CCP is limited. There is need for additional evaluation by independent researchers to assess the performance of CCP. Although the learning gains documented by the CCP Computerized Management Information Systems are impressive, few attempts have been made to examine the long term effects of the CCP. Indeed, with a few exceptions (Robledo et al., 1988; Hahn, 1986; Gittell and Tainsh, 1985;2 and work in progress by Andrew Sum), relatively little independent evaluation of the CCP is available. While CCP's built-in evaluation system is one of the program's outstanding features, built-in evaluation does not substitute for independent evaluation. Although the technology or learning system embodied in CCP may be recognized some day as one of the most significant innovations of the 1980s in education and training, its effects need to be confirmed by independent researchers. In the meantime, CCP is building a formidable network of learning centers and a cumulative data base on learners that certainly will provide samples large enough to produce statistically valid results.

The data collected in the computerized CCP information system have shortcomings. As a prime example, CCP learning gains are recorded only in terms of converted grade levels. Raw test scores are not recorded in the CCP Management Information System. While grade levels and grade level gains may be understood by the lay person, the absence of data on raw scores confounds proper evaluation of CCP learner achievements by the conscientious researcher. This problem may be remedied in an improved version of the CCP Management Information System currently under development.

Despite the fact that the CCP is organized around business efficiency principles and requires annual utilization planning, many CCP centers are inadequately utilized. Although there are notable exceptions, some community organizations have proven unable to attract sufficient numbers of learners to spread their fixed costs over sufficient learners to achieve low per unit costs. The problems of underutilization are different in school-based CCP learning centers. The learning centers in schools generally are well utilized during the day, but few school facilities are open for learners in the afternoons and evenings. The best CCP learning centers have demonstrated that it is possible to achieve significant learning gains at costs as low as $3.00 per learner hour. Contrary to the argument that small class sizes are more efficacious than larger classes, CCP experience has demonstrated that the best utilized learning centers also are producing the largest learning gains (Taggart, 1986; Taggart et al., 1987).

The Writing to Read Program

Reading is a skill fundamental to learning other subjects. It is important to build a solid foundation in reading skills in kindergarten or first grade. Writing to Read, developed by John Henry Martin and marketed by the IBM Corporation, is an approach to teaching reading and writing in kindergarten and first grade that combines components of language arts instruction with microcomputer technology (Willows, 1986, p. 1). The program is conceptually appealing. Based on the premise that children come to school with a working vocabulary ranging from twenty-five hundred to four thousand words, Writing to Read teaches children to write what they can say, then read what they have written.

In order to gain perspective on the challenge of teaching reading, one must understand what makes learning to read difficult. Human beings are programmed to speak; reading is another matter (Willows, 1986, pp. 5-6). First, students must be taught to recognize the symbols used in their native language and second, to "map" those symbols into oral language. In the case of English, those symbols are the alphabet, which is learned quickly relative to some other languages (Willows, 1986, pp. 7-8).

Some programs teach children the alphabet and combinations of the alphabet (words) quickly; others do not. "Mapping" words "onto written language" is more difficult in English because of the inconsistencies of the language (e.g. tough, cough, through, thorough). This necessitates teaching beginning reading with the consistent components of the language (Willows, 1986, pp. 9-11).

Beginning reading programs can be grouped into three categories: phonetics, whole word, and the natural language approach (Willows, 1986, p. 12). Although each is useful and has its strengths, all have serious weaknesses. Phonetics teaches children basic sounds of each symbol (letter) and how to put those sounds together to construct words (*a* as in apple, *t* as in table; *a* + *t* produces the sound found in *at*) (Willows, 1986, p. 12). Children can read the stories independently by decoding the letters to sounds and blending the sounds to match the words they know in oral language (Willows, 1986, p. 13). However, students often learn symbol groupings that mean little to them, making sentences insignificant (e.g., "The flat rat is mad") (Willows, 1986, pp. 13-14).

Whole word programs require children to memorize words that they often use. This reduces the number of words the child must memorize and the repetition of those words reinforces learning (Willows, 1986, p. 15). However, children cannot sound out words they do not recognize, limiting their ability to independently add words to their vocabulary. Some programs get around this by adding a phonics component, but children often confuse words that have similar patterns of letters (e.g., horse-house, can-car) (Willows, 1986, p. 16).

Natural language programs are "designed to focus on the language patterns and interests of young children" (Willows, 1986, p. 17). Since these programs motivate children to overcome the difficulties of "mapping" the language and to learn symbols, the reading material is more interesting to both teachers and students. Children use their oral language skills more in this method than in the phonetic and whole word methods (Willows, 1986, pp. 17-18). However, no special methods exists to help children overcome the two main difficulties in learning to read: inconsistencies in language that confuse children in the early stages and the problem of learning to sound out words (Willows, 1986, p. 18).

Writing to Read overcomes many of the limitations of the traditional programs by teaching reading through writing, which is traditionally taught as a secondary process. Children learn to write the words they already know, personalizing the learning process. The system teaches 42 easily learned spelling-sound patterns (phonemes) basic to English. After learning the entire set, students can write phonemically any word they can pronounce. Standard spelling and the inconsistencies of the English language are learned later. The self-paced program aims to assure that students learn reading thoroughly and that no child is left behind -- even those who may have special needs. The personal computer is programmed in such a way that lessons are repeated until the child learns. Interaction between student and computer frees the teacher to spend more time on other activities. Using the keyboard enables children to write at a time when limited motor skills often prevent them from using pen and pencil (Willows, 1986, p. 20-23).

For approximately one hour per day, children come to the Writing to Read Center where they rotate through several of the five learning stations in the program: (1) At the *Computer Station* students interact in pairs with a computer equipped with a speech attachment that enables the computer to talk to them. The children spend about 15 minutes at the computer, interacting with their partners and responding to instructions given by the computer voice. Through headphones the students hear the sound of each of the phonemes and repeat them. During 10 learning cycles, students respond to exercises presenting the 42 phonemes as used in familiar words, presented with pictures. Upon completion of all cycles, children are acquainted with writing and reading the sounds that make up spoken English. (2) The *Work Journal Station* provides journals and taps devised for the purpose of reinforcing and supplementing the computer lessons. With headphones and tapes, the students hear the phonemes and words they are learning and write them into their journals. On the back of the journal is a progress chart which shows the child's progress through the stations and which each the children mark themselves. Following the completion of a cycle, students take their work journals home for discussion of progress with parents, which encourages parental involvement and reinforcement of learning from families. (3) At the Writing/*Typing Station*, students have access to two learning areas: the writing table and the word processing area. At the writing table, students have access to various writing tools such as pens and paper to draw letters and write words by hand. However, since hand lettering is often a laborious and time consuming task for young children, they also use computer keyboards to type letters and words and progress to writing sentences and stories. Without fretting over creating each symbol by hand, they can build speed in letter recognition, concentrate on what they want to say, and build writing fluency. This method provides a means to encourage a focus on thought prior to the development of motor skills. Soon after their introduction to written language, students can begin to view writing as a means of communicating a thought or message. At this station, many children in kindergarten and first grade progress to the level of actually writing stories and compositions. (4) At the *Make Words Station* students are provided with a variety of manipulative items in games and puzzles designed to provide tactile learning experiences. Using materials such as clay, sand trays, wooden letters, and pipe cleaners, students learn that the letters representing the phonemes can be recombined in many ways to make new and different words (Martin and Friedberg, 1986, pp. 27-28). (5) At the *Listening Library Station*, students listen with tape recorders and headphones to carefully selected children's literature while they follow along in the text. This station is designed to familiarize students with words and their meanings in context to give them a chance to match speech with written English. Gradually the children become familiar with book spelling and include it in their own writing.

Studies of the Effectiveness of Writing to Read

The Educational Testing Service Pilot Study. Under contract with the IBM Corporation, the Educational Testing Service (ETS) tested the effectiveness of the Writing to Read program over a two-year period in pilot schools. Altogether more than thousand kindergarten and first grade students participated at 28 sites. In order to participate, each school agreed to establish a Writing to Read center, participate in third party evaluation, and provide an aide and training time for teachers.

The first year of the project was directed to formative evaluation. The study concluded that the students could handle the technology required: the IBM personal computers, the typewriters, and the tape recorders. Students also handled the movement from work station to work station. Finally, the Writing to Read Program functioned well as a system -- a complex of interconnecting parts.

The second year of study was primarily geared to summative evaluation. The sample included a wide spectrum of school districts, ranging from large urban school systems to suburban and rural districts. The second year core sample consisted of 3,210 children who used Writing to Read and 2,379 children who did not. The basic populations consisted of students in schools selected randomly from participating districts. The schools were in their second year of implementation and had worked out any early implementation problems. The massive ETS study was quite unusual in that it went far beyond the standard "beta testing" (i.e. debugging) that normally accompanies the introduction of new products; it was designed to produce objective information on the effectiveness of the program by an objective team of qualified, third-party evaluators, according to scientific standards.

To gauge student achievement, standardized reading tests normally given by the districts, professionally graded student writing samples, and a standardized list of spelling words were used as measures of effectiveness (Murphy and Appel, 1984, p. 1.5). Whenever there was sufficient data, ETS conducted analyses on subgroups such as male and female, black and white, students of differing socioeconomic status, and "students of relatively high and low initial achievement" (Murphy and Appel, 1984, p.6.4-6.5). Three schools were added to the study in order to target low income and high minority populations. In addition to examining student achievement, parents and teachers were surveyed.

The test results showed that students who used Writing to Read performed better and showed higher rates of achievement than those who did not. On before and after tests, Writing to Read children progressed faster, on average, than the national norm samples and their non-Writing to Read counterparts, especially for kindergarteners. The relative performance of Writing to Read students was even better in writing. In spelling, Writing to Read students performed as well as other students.

The surveys of teachers and parents also found favorable results. Teachers and parents liked the program and hoped it would continue. Teachers reported that Writing to Read students wrote and read better than previous classes. A few added that the program had a notable effect in improving the self confidence of the children participating. The children were delighted with their writing and proud to exhibit it. The program also produced more noticeable results to parents than did traditional programs. Parents reported that the progress of their children in Writing to Read was better than previous children at the same grade level (Murphy and Appel, 1984, pp. 8.5).

The ETS study of Writing to Read has been criticized on several grounds. A key problem in the study implementation, according to the critics, was that children in the Writing to Read program spent more time in instruction in both reading and writing than did comparison students. While any program that engages kindergarteners and first-grade children in more reading and writing activity is desirable, the evaluation was confounded, according to the critics, because the positive effects found in the program may be attributable to increased instructional time rather than to greater effectiveness of the Writing to Read program (U.S. Congress, Office of Technology Assessment, 1988, p. 63). This conclusion is disputed by some who argue that teachers were able to spend more time teaching reading and writing because they could spend less time on teaching phonics and structural symbol analysis that are preliminary to reading. The Writing to Read program was teaching those subjects more efficiently. The ETS study also yielded a few anomalous results. Writing to Read worked better among above-average children than others, and detailed study findings revealed that the reading achievement of some populations studied progressed at equal rates regardless of participation in Writing to Read. Inexplicably, oriental students who did not participate in Writing to Read wrote better than those who did participate.

Volusia County, Florida Study. Volusia County, Florida, was a national demonstration site for IBM's Writing to Read program. Beginning in the 1984-85 school year, the county piloted the program in kindergarten, K-1 transition and in the first grade in three schools. After a successful 1984-85 school year, the program was expanded to 34 schools, including an "Exceptional Student Education School." The school district evaluated the longitudinal effects of the program on second-grade students who began the program in kindergarten (the major focus of the study) and the writing achievement of kindergartners involved in the program during the 1986-87 school year (Blackburn and Davis, 1987, p. 1). The study compared schools similar in size, socioeconomic background, and standardized test scores (Blackburn and Davis, 1987, p.6).

The Volusia County schools used "Get Set for Writing to Read" for students who needed extra help. This program introduces children to preliminary language concepts and prepares them for beginning basal reading programs (Blackburn and Davis, 1987, p. 4). The schools incorporated many approaches, including the use of tapes, games, and writing on the chalk board, to teach the children the alphabet (Blackburn and Davis, p. 4).

In May 1987, second graders who learned to use Writing to Read in kindergarten in the three original schools and those in the three comparison schools were given the National Test of Basic Skills, Level D to determine if there were significant differences in reading and language scores between the two groups (Blackburn and Davis, 1987, p. 7). The students also submitted a writing sample to a blind panel that did not know whom they were grading.

Writing to Read students performed better than those in the comparison schools in total reading skills, "word attack" (the ability to sound out unfamiliar words), vocabulary, and comprehension (Blackburn and Davis, 1987, p. 11). According to the study, the Writing to Read students' higher scores in "word attack" illustrates that the overall scores did not occur by chance. This is a skill specifically taught by and "highly correlated with" the Writing to Read program. Statistical analysis indicated that in a 92 percent confidence interval, the differences were not due to chance (Blackburn and Davis, 1987, p. 11).

Language achievement includes spelling, the ability to organize words and sentences, and expression. The Writing to Read students scored higher in most language skills. The mean spelling score for Writing to Read students was lower but not at a significant confidence interval. This is an important finding because Writing to Read has been criticized for negatively affecting students' spelling skills. (Blackburn and Davis, 1987, pp. 14-15).

Again, Writing to Read students scored higher in written tasks than did those in the comparison schools (Blackburn and Davis, 1987, pp. 16-17). The levels ranged from 1 (lack of ideas, copying words seen in the classroom) to 6 (well developed and expressed ideas) (Blackburn and Davis, 1987, p. 9). Based on writing samples collected throughout the 1986-87 school year, kindergarten students in twelve randomly selected Volusia County schools showed improvement in one year of the program. Improvements in writing were measured on the basis of six progressive stages developed by John Henry Martin (Blackburn and Davis, 1987, p. 18); namely:

Stage 1: Cycle Word Writing
Stage 2: New Word Writing
Stage 3: Phrase/Sentence Writing
Stage 4 : Simple Story Writing
Stage 5: Intermediate Story Writing
Stage 6: Advanced Story Writing

At the beginning of the year, all the Writing to Read students were at stage 1. By the end of the year, 73 percent of these students were at stages 4, 5, and 6. The following year 87 percent of the Writing to Read students advanced to stages 4, 5, and 6 (Blackburn and Davis, 1987, pp. 19-20). Prior to implementation of Writing to Read in 1984, students only advanced to stage 3. The writing samples of the Writing to Read students showed better organization and used more words (Blackburn and Davis, 1987, p. 20).

Writing to Read's active method of teaching is one of its positive aspects. Writing to Read requires students to interact with the computer, select their own materials, and allows them to work with other students. The program encourages creativity because students use their own vocabularies to construct sentences and their imaginations to create stories (Blackburn and Davis, 1987, p. 22).

Portland Public Schools Study. In Oregon, the Portland Public Schools piloted Writing to Read in the 1983-84 school year and evaluated the program in 1984-85. A district coordinator planned orientations for parents and arranged support for individual schools. Building support personnel acted as liaison between individual schools and the district coordinator to address curriculum and equipment concerns. At least two other adult supervisors staffed 22 of the 23 centers (Moilanen, 1986, p. 8). Twenty kindergarten teachers experienced with Writing to Read were chosen specifically to participate in the program (Moilanen, 1986, p. 8).

The district used the study to determine achievement of kindergartners. This study, more than others, focused on student readiness for the program and categorized the students into three groups: Not Ready (34 percent), Ready (59 percent), and Advanced (8 percent). Different expectations for achievement were developed for each of the three categories. The Not Ready group was expected to improve its knowledge of sound-symbol relationships and to complete two to four instructional cycles. The Ready group was expected to compose and complete five to six instructional cycles. The advanced group was called upon to compose, read beginning readers, and complete all ten instructional cycles (Moilanen, 1986, pp. 17-24). This study provided no information about socioeconomic status or ethnic background of the participating students.

The students were asked to read lists of cycle words for placement in the district's accelerated program. The students spent 50 percent of their time practicing sounds and words and 15 minutes per session reinforcing sound and symbol relationships with computerized drill and practice (Moilanen, 1986, p. 37).

The evaluators found that not all the students could read what they and others had written. The kindergartners were not qualified for accelerated reading courses after five months of Writing to Read (Moilanen, 1986, p. 51). Moilanen concluded that there is no defensible evidence that the system is either inferior or superior to other attempts with similar resources to teach writing and reading in kindergarten (1986, p. 52).

Fort Worth Independent School District Study. Technology is not self-implementing. A school cannot simply purchase equipment and materials and expect results to occur automatically. Continued commitment to implement the program properly and to train teaching staff are essential. Perhaps there is no better illustration of this than Fort Worth ISD Kindergartners and first graders participated in the Writing to Read program implemented in the Fort Worth Independent School District during the 1985-86 school year in fifteen schools.

Many inadequacies existed in the initial implementation of of Writing to Read. These included a shortage of supporting equipment, materials, and staff, maintenance problems such as ill-functioning or broken tape recorders and headphones, limited space for the laboratory and for storing equipment, and furniture that was too small for the students. Teachers inadequately monitored student progress so that no feedback was provided when needed. Also, students did not stay on task, and often they did not complete their work journals properly (Naron, 1986, pp. 4-5).

Although the Writing to Read program is designed to be used five days per week for 60 minutes per day, some students only attended four days and the time students spent there varied from 30 to 60 minutes. Often teachers used much of that time in pairing up children and on management duties, thus shortening the amount of time the students spent on task. Occasionally teachers took students to the lab in the afternoon when the students were too tired to perform at peak levels.

Implementation of the program varied from school to school. Schools did not use the same rotation procedure from station to station. Some Writing to Read activities were conducted outside the lab. The tape players were not always used; Naron fails to report whether this was because the recorders were broken or because the teacher simply chose not to use them. Teachers often divided the Writing/Typing station into two component parts. The quality of communication and coordination between teacher and aide varied. Some teachers and aides discussed the program on a day-to-day basis, others only once a week (1986, p. 5). All of these factors negatively affected the results of the program.

Teacher training provided by the district (two days in the summer) did not adequately prepare teachers to use the program. Some teachers were not comfortable with the equipment, and others did not know what to expect from their students. The district developed follow-up sessions for training throughout the year to answer questions and made arrangements for teachers to visit other schools engaged in the program. The coordinator periodically visited all the schools. Still, 10 percent of all teachers believed they needed more in-service training (Naron, 1986, pp. 12-13).

Despite the fact that Writing to Read program requires teachers' aides, Fort Worth ISD did not provide them. Ninety-two percent of all the participating teachers said that they needed aides with Writing to Read to help keep the children on task. Sixteen aides cost the district $169,042 in salaries (Naron, 1986, pp. 32-33). Without additional funding from regular sources, principals and teachers used minigrants, reallocated personnel, used parent volunteers, operated without the aide, or used some combination of all these mentioned. When aides were not available, five of the sixteen teachers did not use the lab at all.

The first collection of data occurred in the fall of 1985 and the second in May 1986. In the fall, four evaluators observed four classrooms during the first and second months. In the spring, the same evaluators observed two to four classrooms each. The evaluations were supplemented by interviewing teachers and having them complete questionnaires. Eighty-five percent of all teachers responded (Naron, 1986, p. 3).

Naron reported that the study conducted at the Fort Worth schools had a number of other limitations. The instrument used as a measure of outcomes, the Iowa Test of Basic Skills (ITBS), is inadequate. It is designed to produce a wide range of results that are normally distributed and therefore are not representative of the objectives of the program. Further, the validity of the scores on standardized achievement tests is questionable at the kindergarten and first-grade levels. For example, at the kindergarten level, a raw score of 24 is about the chance level of guessing (e.g., what one would score if one randomly guessed), but this raw score yields a grade equivalent of K8, which is exactly at kindergarten grade level (1986, p. 29). ITBS is used because the results of the test become more valid with each additional school year and are a good predictor of achievement after fifth grade, making it preferable to other tests. Lack of pretest data handicapped the study as well. The district put the program into place before all the first graders were tested; none of the kindergartners were pretested. Kindergartners from all fifteen schools participated in the program as well as first graders not in multi-age classrooms with second graders. The sample size of second graders was too small to test. Comparison groups were not randomly selected, thus it is unknown whether any differences in outcomes are the result of initial differences or the treatment administered (Naron, 1986, pp. 29-30).

Despite these limitations, the differences in reading scores were determined to be statistically significant for the kindergartners. The scores for the first graders are not statistically significant, however. (Naron, 1986, p. 30). Two schools were dropped from the study: the first graders had not been tested with ITBS in kindergarten, and the other had no kindergartners. The study shows no significant differences in the spring 1985 kindergarten scores and no significant gains (Naron, 1986, p. 31). According to Naron, the data analyses must be viewed with caution. They suggest that kindergartners in the Writing to Read Program scored higher on the reading subtest of the ITBS than did students of similar socioeconomic status in non-Writing-to-Read classrooms, but that first graders in Writing-to-Read classrooms did not score higher than their comparison study group. First graders represented a smaller sample than the kindergarten data, but more complete pretest data were available for them. The 1985 test scores of first graders suggested that the first-grade comparison groups were appropriately matched, but similar data were not available at the kindergarten level (Naron, 1986, p. 31). The district's goal is long-range achievement. Differences between achievement of students in the Fort Worth School District and the national norms do not show up until after the fifth grade (Naron, 1986, p. 32).

Most administrators and teachers liked the program. Of the fifteen principals, only one was apprehensive, and another did not respond. Forty-five of the seventy-three teachers involved liked the program, two were "highly critical," and one was "ambivalent." Another twenty said that the program was good only if implemented properly and if creative writing was emphasized. The teachers aides responded similarly (Naron, 1986, p. 7). Naron alleged that the exuberant reactions of the participants to the results of using something new, experimental, and different from same old thing (Naron, 1986, p. 40).

Teachers reported that the program was better suited for some students than others. However, Naron could find no significant pattern to indicate which students would benefit from the program and which would not. At the end of the 1985-86 school year twenty-nine of the fifty-two kindergarten teachers reported that 75 percent of students were ready to begin with Writing to Read in the fall. Nine schools said that 25-50 percent were not ready, fourteen kindergarten teachers said that over 50 percent were not ready to begin. Twenty of the fifty-two kindergarten teachers reported that less than 75 percent of their students completed all ten instructional cycles. More than half of them reported that 25 percent had repeated at least half the instructional cycles. Sixty-two percent of the teachers observed that the large amount of repetitiveness did not cause kindergartners to lose interest, but the same percentage of first- and second-grade teachers responded that their students did lose interest. All teachers requested more books and materials for less prepared students and for advanced students and wished that materials beyond the ten cycles were available (Naron, 1986, pp. 8-9).

The Experience in Other Texas School Districts. The initial reports from Fort Worth seem to contrast markedly with the Writing-to-Read experience in many other Texas school districts. School districts in Beaumont, Waco, Round Rock and others report enthusiastic support and favorable results from the Writing to Read program. Indeed, more than 200 of the 1057 school district across Texas had adopted Writing to Read in at least one school by March 1989. Within the past five years, nationwide nearly five thousand school districts have installed Writing to Read in at least one school, or almost one out of every three school districts in the country.

CONCLUSIONS

Over the past 30 years, considerable research and development efforts have been devoted to CAI, especially in the use of drill and practice. Generally, evaluations of CAI have shown small but significant gains in basic skills achievement. However, the use of computers is not limited to drill and practice in basic skills and the term *technology* encompasses more than computer equipment, which is only a tool. Technology, in its full sense, encompasses learning systems. This point is illustrated by examining two innovative programs, the Comprehensive Competencies Program (CCP), developed by the Remediation and Training Institute, and IBM's Writing to Read Program.

The Comprehensive Competencies Program has been commonly mis-identified as a system of "computer-assisted instruction" or "computer-based curricula." The computers tend attract attention to CCP; yet it is possible to operate a CCP learning center without any computer-assisted instruction. In fact, CCP recommends that at maximum, no more than one of every three seats in any learning center be devoted to a computer workstation. More than half of the seats in any CCP center are devoted to working with paper and pencil or printed materials.

CCP provides a framework of competencies, along with corresponding lesson assignments and computer-scored tests. Essentially CCP is a way of reorganizing teaching and learning on an individualized, competency-based, self-paced mode (an organizational scheme which is part of the technology itself). Lessons from the effective schools research have been woven into the design of CCP. For example, the CCP is designed to maximize time on task. It is designed to provide students with immediate feedback. CCP is geared to facilitate the learners taking responsibility for their own learning. The CCP makes use of technological equipment such as computers and VCRs as tools to provide a variety of learning media. The entire learning center often is located in a single large classroom -- including computers, audio tape players, video tape players, etc.

Most studies have shown that students in the Writing to Read program achieve more than students in the comparison schools. The Volusia County School District believes that the achievement gains of its students are statistically significant, but the study does not discuss these gains in relation to the costs of the program. The Portland study concluded that Writing to Read is "neither inferior or superior to other attempts with similar resources," but it failed to cite the programs to which Writing to Read was compared (Moilanen, 1986, p. 52). Unknown as well are the costs of the comparative programs or the statistical results. The conclusions would take on more significance had these variables been factored into the study.

Writing to Read students showed greater achievement than those in the comparison groups not just because they used computers, but because Writing to Read was designed as an integrated, comprehensive, multi-sensory learning system. The studies can not differentiate between gains attributable to the use of the computer and those attributable to other variables, such as increased individual attention. The use of teachers' aides in the program increased the amount of individual attention each child received. Technical difficulties that require a year or two to iron out and inadequate teacher training contributed to the small size of achievement gains at some sites. The Volusia County School District and ETS evaluated Writing to Read only after the schools worked out implementation problems. However, even a smooth-running program and experienced teachers apparently did not help the Portland students reach their goals.

Clearly, the best study would take place in a school that has minimized its technical difficulties and that employs teachers experienced with the program. The study should be longitudinal, extending from kindergarten through at least sixth grade with adequate amounts of lead time for pretest data. According to Naron, achievement gains are difficult to measure and assess until after the fifth grade. The study should measure outcomes for subgroups and determine cost-effectiveness based on all test results.

All except the Portland study reported that the majority of participants liked the program and wished to continue using it. However, as Naron pointed out, it is difficult to determine if the teachers, aides, and principals liked the program because it facilitated the learning process or because they enjoyed using a new method to teach reading and writing. For children, Writing to Read aims to create an interrelated environment where children become excited and motivated about learning to read and write. The focus on creative self-expression through written language promotes a high level of enthusiasm.

Responding to teachers who complained that Writing to Read covered reading only through first grade and that no follow-up programs were available for use beyond the second grade, IBM consultants have developed a program entitled, "Teaching and Learning with Computers," or TLC, which teaches reading, writing, and grammar through the fifth grade using a learning-stations approach and heavy emphasis on word processors as writing tools, along with various courseware to teach basic language and grammar skills. This program is designed for use in a regular classroom rather than in a lab, as is Writing to Read. IBM piloted this program in 14 sites throughout the nation before it became available on the marketplace in the 1987-88 school year. In addition, John Henry Martin has developed a follow-up program entitled "Writing to Write," which was being field tested in early 1989. Writing to Read has become available in Spanish as well as English, and in two computer configurations -- stand-alone and networked models. The stand-alone model requires users to handle individual diskettes. The networked model stores all the software in a file-server, which the user accesses from the keyboard and which can be pre-programmed by the teacher.

A comparison of the Comprehensive Competences Program and the Writing to Read program reveals important similarities. Both programs radically restructure the management of learning in the classroom. Just one visit to a CCP learning center or a Writing to Read lab is enough to point out that something significantly different is going on here. Both CCP and Writing to Read significantly change the role of the teacher so that more emphasis is placed on motivating learners, working with them on diagnosis and prescription, and tutoring one-on-one and less emphasis is placed on lecturing and grading tests (other than essay tests or others than cannot be machine scored.)

Both CCP and Writing to Read classrooms are learner-centered rather than teacher-centered. Both emphasize a mastery learning approach to education. Both use an individualized, self-directed and self-paced approach to instruction that places greater responsibility for learning on the students themselves.

Both CCP and Writing to Read are grounded on a strong research base. John Henry Martin, creator of Writing to Read, was heavily influenced by the work of Maria Montessori, Jean Piaget, Benjamin Bloom, and others. ETS conducted a massive nationwide evaluation of pilot Writing to Read sites for two years before the IBM Corporation brought the program to market. Similarly, Robert Taggart, originator of the CCP, borrowed from research on the Job Corps and other programs for disadvantaged youth, as well as the literature on effective schools. CCP was pilot tested for a year before it was made generally available, and continuing research and self-evaluation are integral elements built into the design of CCP.

Although both CCP and Writing to Read are identified strongly with computer-based instruction, computers are used only in a minority of the workstations in each. In Writing to Read, computers are used in two of the five workstations. In CCP, computers are recommended for no more than one-third of the workstations in the classroom. In both systems, computers do not replace teachers; rather the computers extend teachers' capabilities and change their roles. Both systems also make effective use of teachers' aides and volunteers in the classroom. Experience with both systems has demonstrated the importance of proper implementation and staff training. The critical human factors issues should not be underestimated in the implementation of any new educational technology.

Both CCP and Writing to Read are in need of continuous evaluation to confirm results and to make improvements. Purchasing these programs is a significant investment. As other school districts across Texas are faced with the decision to implement computer-assisted instruction, the state -- working with individual school districts -- should conduct independent, longitudinal evaluations of the promising programs already in place. It is clear from experience to date, that such high-quality evaluation will not be undertaken if left to individual school districts on their own.

Chapter 3. The Use of Computers in Teaching Mathematics

MATHEMATICS EDUCATION IN THE U.S.

Technological growth is dependent on an understanding of scientific phenomena, which in turn depends on an understanding of mathematics. Mathematics is truly the language of science. Mathematical concepts have important applications in science, such as the use of derivatives in physics or the application of geometric forms to biological structures. Mathematics is also required to understand production systems and statistics. In short, mathematics provides the means to understand and implement much technology (Steen, 1986a).

Despite the importance of mathematics and science learning, the performance of American students in math and science is increasingly perceived as inadequate (Ezra, 1987, p. 65; "Report details..." 1986, pp. 36-37; McKnight et al., 1987, pp.12-29; Dossey et al., 1988, pp. 15-17). American high school seniors ranked 14th among 15 industrialized countries on the most recent tests of mathematics performance ("The Education President," 1988, p. 7). Indeed, in recent international competitions, the average Japanese high school student demonstrated higher levels of achievement than the top 5 percent of American students enrolled in college preparatory mathematics courses (Dossey et al., 1988, p. 8). Most high school mathematics curricula worldwide include a year of calculus; in America, calculus is considered an Advanced Placement course (Steen, 1986b, p. 35-36). Inadequate mathematical preparation may be one reason why the United States graduates the same number of engineers as Japan despite having about twice the population (Caldwell, 1984, p. 562). Whatever the cause, mathematics education is a problem that needs to be addressed in an economy whose growth depends on science and technology. Mathematics education needs to be improved for all Americans -- especially for minorities. Only 35 of the top 10,000 black students entering college desire a degree in mathematics (Steen, 1986a, p. 2).

The quality of mathematics instruction in the United States suffers because qualified teachers are not available. Half of all high school students receive mathematics instruction from teachers not fully certified or not eligible for certification in mathematics (Steen, 1986a, p. 3). The problem is especially acute in rural areas where advanced mathematics and science classes are not offered in large numbers. Further, the massive retirement of post-war era teachers in the next decade will compound the teacher shortage. Given the shortages of masterful teachers of mathematics, can computers help improve learning and motivation in mathematics?

THE USE OF COMPUTERS AS AN AID TO INSTRUCTION IN MATH

The computer is first and foremost a numeric machine, capable of vast computational power. As such, its most natural and most powerful application in education would appear to be in mathematics and other quantifiable areas, such as science. This chapter investigates the use of computers in mathematics and mathematical applications in science. Consistent with an orienting hypothesis of our project, the incorporation of new technology requires an understanding of its systemic implications.

In many schools, computers are still in their first stage of use as aids in administration and for teaching programming (National Governors' Association, 1986b). While these uses are certainly worthwhile, they only scratch the surface of the machine's potential. Likewise, computers are also commonly used for the simplest form of computer aided instruction (CAI) such as drill and practice exercises. While drill and practice can be beneficial, they basically involve automation of existing learning techniques. Beyond the aspect of results kept automatically by the program, students in drill and practice exercises are not doing anything that could not be done without a computer (NCTM, 1984, p. 24). Kulik (1983a) has found the effect of early CAI to be small but significant improvements, including better attitudes toward learning and a reduction in task time of up to one-third.

What can be done with this time and increased enthusiasm? This chapter explores new techniques and new material made possible only with the use of the computer. The computer should not simply replicate what is already done in the classroom. It is an open-ended technology, limited primarily by the amount of creativity with which it is used. There will always be some new technique or topic to teach with computers. Applications programs, such as spreadsheets, programming languages, and data base managers, can be used as general-purpose tools for developing new teaching matter and strategies. Although the computer is no panacea for learning problems, it offers new alternatives in resolving them.

The computer offers a unique resource, especially in its ability to store and easily access large amounts of data and its quick computational power. The advantage the computer offers over other large depositories of data (such as a library) is that this information can undergo complex manipulations through large numbers of computations. These can be logical as well as numeric. The possibility of manipulations allows dynamic, and particularly graphic, illustrations of material (Fey and Heid, 1984, p. 28). Finally, as instruments, computers are easy to use (compared to say, a compass) and allow precise interpretation of directions. That is, a solid relationship exists between what the student inputs and what the computer produces.

One example of the logical power of a computer in teaching mathematics is diagnostic software to identify a student's problems in learning arithmetic. Diagnostic software extends drill and practice methods into real tutoring. In addition to providing individualized pacing, such programs can suggest individualized remedies. These programs depend on two structures of error. One is stability of errors, the tendency of the student to make the same kind of mistake, especially when attempting to inappropriately apply previously learned properties to new problems. The other is linkage, the tendency of the student making one type of error to make a similar error. Problems are designed with the knowledge that students are susceptible to certain error classifications. When evaluating the student's answer, the program can check both the final answer and steps along the way (for example, partial products in multiplication) for results signalling those particular errors. On-line tutorials can provide illustrations of troublesome properties. By keeping a history of the students' errors, lessons can be tailored to meet individual needs and to test for similar errors. Results from these programs have been encouraging: in one study, a program for multiplication was 72 percent successful in error-identification and resulted in test score improvement of 23 percent, compared to 11 percent improvement in the control group (Travis, 1984, p. 215). While diagnostic software is valuable in teaching simple arithmetic and the properties of arithmetic, it can also be applied to more advanced topics such as algebra (Wenger and Brooks, 1984, p. 217-231). Designing diagnostic software for algebra is possible but more difficult because algebra cannot be broken down mechanically the way arithmetic problems can; thus, the program cannot track the process -- and the potential mistakes along the way -- as easily.

While the use of computers in teaching arithmetic is impressive, there is also a bit of irony here. The very technology which facilitates teaching of arithmetic, by its ubiquity, makes it a less important skill (Fey and Heid, 1984, p. 23). Understanding basic arithmetic is important, but knowing how to compute 567 x 239 by hand has been made obsolete by the use of hand calculators which can do the task faster and more accurately.

After simple, single-digit, arithmetic is learned (the importance of which can not be understated), the time usually spent on learning complex arithmetic can be used for other topics. A more realistic topic is that of estimation for quick mental arithmetic. To use the example above, 567 x 239 can be approximated by 600 x 200. Not only is this a very practical skill, it is a launch pad for discussion of numeric properties such as precedence of operators and the importance of relative magnitude in arithmetic. For example, why is 600 x 200 a better estimator for 567 x 239 than 300 x 100 is for 267 x 139? Problems in dealing with magnitude arise often in real life. For example, using an absolute scale such as profit, how could an increase from 1 to 2 be misrepresented as more substantial than an increase from 50 to 75? These and other examples can be worked through on hand calculators or through simple BASIC programs.

An impediment to implementing this approach is the resistance of teachers to using computational devices in mathematics classrooms. In 1982, one third of eighth grade classes prohibited the use of calculators and only in 10 percent of classes was their use consistently high (Steen, 1986a, p. 3). Such resistance also can be expected for computers. The common attitude has prescribed hand calculation of complex arithmetic as the only way to understand it fully (NCTM, 1984, p.21). The extent to which complex arithmetic reinforces arithmetic knowledge deserves investigation. To the extent it does, drill and practice software could be a productive way of teaching complex arithmetic. But again, the ubiquity of calculators minimizes the importance of ability in complex arithmetic. Though working on complex arithmetic can develop skills of precision and accuracy, the use of programming and spreadsheets in computer math courses can achieve the same results in a more general setting, that of algorithmic problem solving (NCTM, 1986, p.23). The use of computers should reduce the amount of time spent on mechanics. Arithmetic properties, however, remain important.

There is some evidence to demonstrate that computers can improve the efficiency of learning for students at the lower end of mathematical skills. The study of mathematics is very hierarchical, continually building a foundation for further learning. Thus, differences in mathematical ability are magnified by placing students into tracks corresponding to their abilities, thereby establishing a pattern and rate of advancement early on. Computers provide two possible antidotes for this: (1) individualized learning on computers allows students to catch up to higher levels and (2) computers can reduce time spent on mechanics, providing increased time for focus on properties (Fey and Heid, 1984, p. 27). Students unencumbered by mechanics may find the properties by themselves easier to understand.

Emphasizing properties over mechanics is a systemic approach that has implications for teaching all mathematics, not just arithmetic. For example, while it is important to know algebraic properties such as a(b + c) = ab + ac, rules of exponentiation, systems of equations, and how to solve linear equations in one variable and quadratic (second degree) factoring, being able to perform manipulative gymnastics with complicated functions appears to be unnecessary. Such skills can be taught in later electives for those who wish to pursue more creative uses of algebra (Fey and Heid, 1984, p. 29). In fact, many exercises (especially in factoring) are contrived to fit certain patterns so as to have a simple solution. Rarely do functions in real life fit into such neat patterns. These patterns each have characteristics which can be learned and applied to similar problems; thus, it is questionable whether students are learning algebra or merely the rote methods necessary for reproduction on exams. Increasingly computer programs can take care of complex calculations. The situation is analogous to illustrating linear equations graphically: it can only be done physically in two or three dimensions; however, the same principles apply to equations of higher dimensions and students can extrapolate from what they know in the second or third dimension (NCTM, 1984, pp. 21-23).

The prospect of accelerated learning exists when we establish the basic principles and let the computational power of the computer develop more complicated examples. For instance, when students understand how to solve simple two-variable equations, they also know the steps for solving equations of a higher order. These steps (an algorithm) can easily be programmed or put on a spreadsheet (Spero, 1985, pp. 88-90). This example illustrates the benefit of the computer's "cheap" computational power. Having students do these exercises by hand would first of all confuse them with the sheer complexity of the systems of equations but also be "expensive" in terms of time spent on calculations. Using the power of spreadsheets can be a springboard for discussion of matrices (a spreadsheet can be thought of as a collection of matrices), higher-order polynomials and other topics usually not discussed until the third year of algebra or even college. A spreadsheet is a particularly strong tool for mathematics. It is a very flexible instrument, allowing the user to set up any number of relationships using most mathematical functions. These relationships can be copied throughout the spreadsheet to examine values with different inputs.

The spreadsheet is to mathematics what the word processor is to writing: it takes care of the routine aspects so the learner can focus on content. Its ease of use gives it an advantage over programming languages, which require knowledge of syntax and input/output methods; one can simply start entering formulas. Recent spreadsheet programs have come down in price ($50 to $200) while offering advanced tools like matrix manipulations and statistical techniques, including regression. Once created, templates illustrating topics can be easily and cheaply disseminated (Spero, 1985, p. 90). Topics such as probability statistics and combinatorics (the study of combinations and permutations), which are calculation-intensive, can also benefit from computerization (Swift, 1984, pp. 107-117).

The ability of spreadsheets to graph data points illustrates another ability of computers: to provide instant, dynamic graphic representation. Equations can be altered slightly and the effects seen instantly. Graphs can be overlaid to show points of similarity and difference. This is important for finding the roots of equations (those values of x which cause y to equal zero), solving systems of equations (by showing points of intersection), and showing properties of higher degree polynomials (points of inflection, increasing or decreasing values of y, and minimum and maximum points). The ability to illustrate equations has a very important role in trigonometry, geometry, and calculus. Reducing the amount of computational overhead required to manipulate and graph equations should make it easier for students to grasp these topics at an earlier age. Using the graphic capability of spreadsheets as the centerpiece for developing these topics blurs the line between them, pointing to another systemic implication of technology: the traditional hierarchy of mathematics can be more flexible. For example analytic geometry (the algebra of forms such as ellipses) is a topic usually taught only in calculus courses. However, the ease of combining the algebra of a spreadsheet with the computer's graphing ability can make this accessible to a geometry class, where such forms are introduced without the algebra, at a earlier point in the curriculum (NCTM, 1986, p. 27). Learning calculus principles or concepts can be made more accessible with graphic techniques which show the tangent lines to a function at different points along the curve (the slopes of which are the values of the first derivative) and how rectangles can be used to approximate the area under a curve (integrals allow the number of rectangles to increase to infinity to find the exact area). There is anecdotal evidence that such techniques increase students' enthusiasm about learning. There also is anecdotal evidence suggesting that some students respond better to traditional pencil and paper exercises (Payne, 1988, p. 1). These findings coincide with another orienting hypothesis of our project: there is no one best way to learn. Computers are important as an option, as an alternative path to comprehension.

Students learning algebra can benefit greatly from use of spreadsheet models. One of the leading misconceptions fostered in algebra is that variables have definitive values for which equations are to be solved. This can be true where incomplete information exists but there is some equation stating the relationship between the known and the unknown (the variable). However, equations often state relationships of factors dependent on decisions (policy variables). A variable as such is exactly that: it can take on different values; its value is not pre-determined. A real life example is the relationship between the price and quantity demanded of a product. The computer, through its computational power, allows us to examine a wide range of changes, a variability not possible with hand calculations or, for that matter, hand calculators. A spreadsheet allows a variable value to be placed in a single cell. When that is changed, the results will be reflected throughout the model. Such sensitivity analyses are invaluable in forecasting and planning. Dealing with incomplete information is a fact of life. Understanding the degree to which our assumptions about values and the relationships between them are sensitive to changes is important for critical thinking (NCTM, 1984, p. 26).

Such sensitivity analysis can take place in the context of exciting applications which computers make possible. Traditional mathematical applications in classrooms have been word problems, which suffer from simplicity and a contrived quality, their lack of relevance to the real world (NCTM, 1984, p.13). The storage and computational power of the computer make possible models dependent on many relationships and large data sets. Combined with its dynamic graphical ability, the computer can be used to produce complex simulations. One simple but powerful example is projectile motion measured by time and distance. Graphing time and distance illustrates speed and acceleration, which are the first and second derivatives of an equation relating time and distance. Another more visual application provides a simulation of traffic conditions at an intersection, allowing the student to vary factors such as speed limits and the timing of traffic lights to avoid situations in which drivers may not be able to stop in time for red lights (Laio and Piel, 1984, pp. 97-106). Yet another application illustrates the principles and mathematics of flight (Wortman and Taylor, 1987). Statistics using large data sets are now easily accessible. Population dynamics can be readily programmed in BASIC (Arganbright, 1984, pp. 184-193). The link between theory and experience is important, allowing the integration of knowledge applied to problems. Much attention has been given to using computers for development of meta-cognitive, or higher-order skills, allowing students to test hypotheses and identify gaps in the data. Such simulations allow students to experiment with their assumptions and recognize where their mathematical skills apply (Urban Institute, 1986; Fey and Heid, 1984, p. 26). Applications are a way to contemporize the subjects of mathematics and counteract the presence of old texts. Many new topics in mathematics -- fractuals, for example -- are used or arise to explain scientific phenomena (Steen, 1986b, pp. 35-36). Some suggest that applications be moved to the beginning of topics, rather than their traditional place at the end. Introducing applications at the beginning can increase student interest by illustrating concepts, then showing the mathematical principles underlying them (NCTM, 1984, p.25). Again, this is a systemic implication of technology.

Mathematics applications are often scientific, reflecting that mathematics is the language of science and technology. Applications blur the line between mathematical topics and between mathematics and other topics. An example is an archaeological project in New Mexico undertaken by fourth-grade bilingual students. Not only are these students uncovering 11th century artifacts, they are learning excavation techniques and to do that they are using the LOGO language to learn the geometry of surveying (Ortiz, 1987).

Geometry naturally benefits from the dynamic graphics capabilities of computers. Color can highlight salient parts of forms, such as congruent angles, and animation can display similarities such as one side of a parallelogram sliding down to the opposite side, illustrating equivalent measurements (Hativa, 1984, pp. 89-96). However, it can also take advantage of its interpretive power. Using LOGO, a simple interactive language allowing students to guide a pen a certain distance or to create an angle, students can construct various polygons to explore their properties or test hypotheses of congruence (NCTM, 1984, pp. 39-40). Compass and protractor programs produce much the same effect. Again, sensitivity analysis can be applied to measure the effects of changes in assumptions. The advantage of LOGO is that it follows an intuitive command structure that can be saved and altered. Applications include using vectors to describe motion and force (a link to algebra), the properties of forms--for example, which dimensions of a can minimize the surface area given a constant volume -- (a link with calculus), pattern-recognition, and robotic motion (Channell and Hirsch, 1984, pp. 171-183).

Current attempts to integrate computers into the mathematics curriculum often come under applications such as computer mathematics and business mathematics. While these include some interesting applications, there is potential for unnecessary rehashing of topics already learned in mathematics courses. For this reason, the National Council of Teachers of Mathematics recommended against using computer courses for mathematics requirements (Steen, 1987b, p. 9). There is also the danger of isolating the benefits of computers from mathematics courses, though such computer courses can serve as testing grounds for new methods of teaching mathematics. There is also the possibility that programming will be taught to the exclusion of applications and mathematical principles. Programming knowledge is valuable in and of itself, but the point of integrating technology into curricula is as a tool, not as an end in itself. Using applications to model and solve problems is easier and more realistically the way most people will use computers. Learning how to program may develop higher-order, logical thinking skills. However, there is debate whether programming skills are general skills or only narrow, procedural, algorithmic reasoning. These issues deserve further attention.

Computers offer new opportunities, not just more efficient ways of doing the same thing. The pace of technology (especially when considering the time needed for worthwhile research) makes assimilation difficult. However, computers make possible new ways of teaching that should not be ignored. Their systemic implication is that much of mathematics curriculum can now be a given rather than a goal. Such elimination of routine tasks is characteristic of technological change. Freed of excessive mechanics, students can pursue more challenging and creative projects.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Mathematics is a troubled subject area in American education. American high school seniors ranked 14th among 15 industrialized countries on recent tests of mathematics. This has grave implications for our nation in an international economy driven by technological change.

The computer's power to perform vast numbers of calculations instantaneously affects mathematics learning more than any other subject. As essentially numerical tools, computers have great potential not only to aid traditional mathematics education but to transform it in many ways and to create new modes of learning. Beyond creating electronic versions of drill book exercises, a computer can serve as a diagnostic tool for identifying students' errors. Such software exists for arithmetic and there is promising material available for algebra, though it is more difficult to produce.

Though the importance of understanding basic arithmetic can not be overstated, the ubiquity of calculation devices in everyday life makes spending large amounts of time on complicated arithmetic manipulations unnecessary. Time could be better spent on understanding common mental tasks such as estimation and appreciating the relative magnitudes of different numbers. Fundamental properties, of course, remain important. Continued resistance to the use of calculators in classrooms does not bode well for integrating computers into the curriculum. A prevalent attitude is that extensive drill exercises done by hand are the only path to fully understanding the material and that this develops an important outcome of mathematics learning, precision, and accuracy. Arguably, however, working with computers fosters the same skills.

Currently, too much time is spent on performing complicated manipulations for a narrow group of problems which fit a certain few patterns in order to yield answers. It is questionable whether students are learning the subject matter or merely rote methods. By firmly establishing the principles, computers can serve as springboards for accelerated learning, teaching topics whose main barrier to understanding has not been the concepts but the amount of calculations involved. Examples include systems of equations and statistics.

Spreadsheets are an excellent general purpose tool for teaching mathematics. They allow manipulations of complicated equations, even matrices, and their graphing ability offers a different way to look at and understand symbolic equations. This dynamic illustration of subject matter suits some students better than traditional pencil and paper exercises.

The graphic medium blurs the line between hierarchical divisions of subjects. Algebra, geometry, trigonometry and calculus have interdependent relationships based on forms and shapes. With their ease of calculation and instant illustrations, computers can bring together these topics and allow understanding at earlier grade levels. The computer's graphic powers are especially relevant to geometry.

Computers permit the teaching of real mathematical applications, instead of the artificial word problems so often used. Cross subject matter includes economics and social statistics as examples. Most exciting, though, are simulations and the illustration of scientific phenomena. Mathematics often has been developed for the purposes of scientific modeling.

Through the use of individualized computer instruction, poorly performing students may be able to catch up and break through tracks of advancement which have isolated groups of students according to the ability they showed in early grades.

The prospects for computer-integrated curricula for high school and upper-level elementary mathematics are too advantageous to be ignored. Current attempts at integrating computers into the curriculum often result in hybrid courses, such as teaching programming with assignments requiring illustration of mathematical concepts. Such courses may use the computer as an end in itself rather than as a tool in an enhanced curriculum. They often cover topics better taught in true mathematics classes. Full integration of computers into mathematics curricula offers new opportunities-- not just more efficient ways of doing the same things.

To fulfill the potential of computers in the teaching of mathematics, proper resources are required. No special hardware is required; a single computer with a high-quality monitor will suffice for many techniques, though a laboratory of workstations is necessary for exercises. Proper software and textbooks are more difficult to procure. More intensive simulations and applications will require more sophisticated software with higher integrated quality, especially in graphics. Incorporation of computer applications and techniques should accompany the use of textbooks. Given the time necessary to develop and implement new textbooks, alternative instructional materials may be needed. Traditional materials can be augmented through informal and formal networks, developing, sharing, and disseminating BASIC programs, spreadsheet models, creative applications, and new ways of presenting material.

"Hybridization" between computer literacy and mathematics should be avoided; a distinct line should be drawn between computer and mathematics classes. No class of one kind should serve to fulfill requirements in the other area. Computers should be used directly and fully in teaching mathematics the first time around--not used to duplicate material that has been taught earlier. Computer courses should fundamentally be independent of mathematics curricula; computer courses should concentrate on programming, information systems, applications, foundations of the technology, and social implications.

Applications across subject material, linking to topics in science and social studies, should be encouraged and, when possible, coordinated for mutual benefit. Teachers should be encouraged to teach topics not usually taught in high school, such as statistics and linear programming, which are made possible with computers.

The issue of how much work in complicated manipulations is necessary for comprehension begs for further inquiry. However, this question should not impede those willing to fully integrate computers into the curriculum. Full integration has implications for curriculum structure and for the measurement of achievement. Flexible hierarchies would allow classes to move at their own pace. There should be several levels so students can learn at a pace with which they are comfortable. Traditional options should remain for those who prefer them. Flexible hierarchies circumvent traditional, grade-by-grade, subject-by-subject ladders of achievement by placing less distinction between topics and often combining them. Alternative ways of measuring achievement, perhaps testing for credit, may be necessary.

Demonstration projects could point out the strengths and difficulties of a computer-integrated approach. Such projects would probably work best in larger schools, possibly ones with a mathematics specialty. Participation should depend on the inclination and resources of a school. Though computer-integrated curricula may work best with students able to work at an accelerated pace, such curricula should not be reserved for the elites. Full effort must be made to develop and test techniques for less advanced students, including those who have difficulty mastering mathematics.

Chapter 4. Distance Learning

Nearly 75 percent of school districts across the United States enroll fewer than 2,500 students; over half enroll fewer than 1,000 students; and over one-fourth enroll fewer than 300 students (Kennedy, 1987, p. 1). Rural schools face unique challenges in providing instruction due to smaller size, lower funding levels, and geographic isolation (McCormick and McCormick, 1982b, p. 1). Declining enrollment and the need to improve the quality of education in rural schools have led to various reforms and to consolidation of both schools and school districts. Consolidation allows schools to combine resources, increase their student base, and expand offerings. Consolidation has worked to some extent, but at the cost of greater travel time for students and losses to communities of school facilities and jobs (Hobbs, 1985, p. 3). Also, to date, major consolidation of school districts has been rejected as a policy option in Texas. Having nearly reached the limits of consolidation as a solution to the problems, more attention needs to be focused on technological and organizational innovations (Hobbs, 1985, p. 3).

Sher (1981, p. 9) suggests that school innovations are an important way to alleviate problems of rural areas. He stresses innovations because rural communities have rejected the status quo to solve the problems of increased cost and travel time. "This dissatisfaction has, in effect, reintroduced the question of how best to meet the needs of children in sparsely populated areas and has forced policymakers to more critically rethink their past responses to this query" (Sher, 1981, p. 12).

A major challenge is offering a broad and varied curriculum in rural schools. Texas House Bill 246, which amended Chapter 75 of the Texas Education Code, effective in fall 1985, stated that school districts are required to provide each student the opportunity to take more than 30 required courses which make up a "well balanced secondary curriculum" (Barker and Logan, 1985, p. 1). The fact that Texas has more independent school districts than any other state in the nation makes the delivery of such a diverse curriculum difficult. However, the Texas Education Code does allow schools the option of using technology to deliver these required courses.

AVAILABLE TECHNOLOGY

A wide variety of technology is available to provide additional curriculum to rural schools. In order to understand the policy implications of the technology, it is necessary to gain a better understanding of the options. One of the most popular forms of technology is distance learning, which includes numerous variations. For the purpose of this report, the term *distance learning* or *distance education* is defined as recognized learning that takes place at a site remote from the point of origination (Goldstein, 1984, p. 4). Distance learning has the potential to address a wide range of educational issues that involve equity, opportunity, audience, and need. Distance education can help states to meet new curriculum requirements, provide courses for which a certified teacher is not available, and offer quality teacher in-service training. Distance education may be one of the most important strategies for improving education in rural schools, through providing opportunities to offer essential curricular diversity (Barker, 1985, p. 35-37).

Distance education has several attractive features. It can provide equity and increase educational opportunities for students. It creates opportunities for interaction and joint activities with students in other schools (Batey and Cowell, 1986, p. 3). Distance education is flexible; it works effectively for large or small classes. Some technologies address full classes while others are designed for individual students. Distance education is not curricula specific; all subjects can be presented, from languages to science classes. It can be used for presenting entire courses or for supplemental instruction. It has been demonstrated to be effective, especially with students who are independent self-starters. Distance education comes in a variety of forms, some of which are as inexpensive as using the telephone. Given all the benefits of distance education, it has attracted increasing interest from both politicians and educators over the past few years.

One popular branch of distance education is the use of satellites for the transfer of information. "For small and rural schools particularly, satellite instruction equalizes access to educational resources by overcoming barriers of distance and geographical isolation" (Barker, 1986, p. 15). Several delivery systems currently provide instruction to school districts in Texas, including TI-IN, and those developed by Oklahoma State University and Utah State University.

TI-IN is the largest private venture in the nation delivering K-12 instruction via satellite. Originating in San Antonio, it is the most widely distributed and fastest growing educational satellite network broadcasting interactive satellite programs in Texas and other states. It offers a broader curriculum than the Utah State or Oklahoma State programs. TI-IN's programming includes Calculus, Latin I, Computer Science I, Psychology, and French I. Its live broadcasts are televised five days a week, and lessons are submitted to the Texas Educational Agency for approval. TI-IN does not use computer-assisted instruction as do other satellite programs; rather it uses traditional teacher/student recitation patterns. TI-IN services extend beyond high school classes, offering programs for K-12 classes, in-service training for teachers and administrators, staff development training, and test reviews for teachers and students (Barker, 1986, p. 7).

Oklahoma State University has developed a satellite instruction system that offers extensive in-service training, K-12 student enrichment programming, and complete course instruction. Lessons are broadcast three days a week; on nonbroadcast days, students work individually at their schools on computer-assisted lessons that have been specifically designed by OSU educators. Instructional software includes speech generation and recognition in which students hear correct pronunciation and practice orally (Batey and Cowell, 1986, p. 8). The students watch the teacher on a television monitor that receives the satellite signal through the school's downlink dish or through a cable system which receives and distributes the signal. Live audio interaction is possible by audio link over phone lines (Barker, 1986, p. 4).

Utah State University has a program similar to that of Oklahoma State, with 40-minute telecasts two days a week and the use of computer software programs. Both use televised satellite broadcasts, computerized voice synthesis, and other media. However, Utah State's delivery differs from the others in that it uses taped video lessons, not live instruction. The broadcasts are one way with no audio talk-back component for students. However, students are able to call the instructor with the use of a toll-free phone number (Batey and Cowell, 1986, p. 8).

Other available satellite systems are not yet used in Texas, including those developed by Eastern Washington University with the Washington Educational Service District 101 in Spokane and by the state in Minnesota. Eastern Washington University provides the uplink and the service district provides the educational coordination. The network is new, and is beginning to expand to other states. In Minnesota, 50 school districts have the capacity of live two-way video and audio. Each school district has television classrooms equipped with cameras and monitors so that it can send and receive classes. Any of the 50 classrooms can be the source or the recipient of remote teaching.

Satellite systems have several advantageous features. Teaching foreign languages can be enriched by incorporating additional film resources into the instruction, such as foreign commercials, political dialogue, economic analysis, and cultural and historical information.

Through these resources, the teacher can provide a cultural context not available in the traditional classroom presentation. Receiving schools also can use the electronic mail network for messages, instruction, advice, test information, and evaluations (Hobbs, 1985, p. 22).

Other techniques of providing distance education to rural schools include interactive television, audio conferencing, videotext, electronic pens, and electronic mail. Interactive instructional television, used in Minnesota, operates on a regular television signal to provide experiences similar to those when using the satellite programs. The signals can be carried by microwave, cable, or low power television. The use of interactive instructional television provides great flexibility in curriculum, and helps overcome barriers of distance, transportation, and cost in providing quality programs to rural schools (Hartz, 1983, p. 20).

Audio teleconferencing is similar to interactive television but limits the two-way interaction to audio; no visual information is transferred. The two-way conversation is made possible by linking telephone calls as an operator would or through the use of other audio techniques (Wall, 1985, p. 2). Videotext allows the user to access a data base from home, using a telephone line with a modem or cable to access a distribution center which responds to user requests for particular information. Information is displayed on a television screen in text or as a graph; a hard copy can be obtained by use of a printer. The advantage of this system is that it can provide corrected and updated information to the student. Videotext is also considered an interactive technology because the user identifies the information being accessed (Zucker, 1986, p. 18). Audio teleconferencing is used in Wisconsin.

When the telephone is used for distance education, it provides interactive audio but lacks visual aides. However, a technology called Cyclops, invented in Britain, provides students and tutors with an electronic blackboard on which they write with an electronic pen on a television screen. A microprocessor interfaces with a standard audio cassette player, connected by a modem to telephone lines used for transmission. Messages are sent out over the telephone line. This system provides sound with a video presentation. The technology needed for this is not complicated (Zucker, 1986, p. 25).

In Oregon's Willamette Valley, numerous schools offer fiction writing through the use of electronic mail. Students and teachers use this system to send lessons and assignments to and from remote areas. Students write and correspond with a master teacher through computer hookups (Batey and Cowell, 1986, p. 5). Similarly, many states offer computer networks (terminal connected to a mainframe) to rural schools. The network is provided either through microwave hookups or dedicated telephone lines (Wall, 1985, p. 5).

POLICY ISSUES OF DISTANCE LEARNING

Large discrepancies typically exist between the courses available to students in rural and urban districts. Distance education can help narrow this gap and improve the equity of offerings provided students in rural schools. In a report by the Utah State Office of Education, 82 percent of the state educators surveyed stated that providing equity was the primary focus of technology-based distance learning projects in their states (Eiserman and Williams, n.d., p. 12). Telecommunications can enhance the educational programs in communities that lack the revenue or staff to offer the variety of courses required by state laws. More distance programs are targeted at the high school level than lower grades because high school students need the additional courses to prepare for higher education.

School districts in Texas must follow state-mandated curricula. Yet often no qualified teachers are available in rural districts to teach some of the mandated courses -- even if schools are willing to provide a course with only a few registered students. Along with many other states, Utah has experienced such a dilemma. State universities wanted to raise education standards, so they added a foreign language entrance requirement . Many rural Utah schools could not provide the required foreign language instruction because they did not have the funds to attract foreign language teachers. Utah was compelled to create a successful distance-learning project for Spanish instruction. It subsequently has been adopted by several other states.

Questions about the Educational Framework

Since affluent areas are more likely than low-income areas to have access to advanced technologies, states need to ensure that disadvantaged students are given equal opportunity to utilize technological systems. This raises a question on the proper role of the state beyond the distribution of funds to local schools and districts. With the wave of reform in education that has taken place recently, Texas has added mandates and restrictions aimed at improving its educational system. Yet, with telecommunications-based innovations in education, states are dealing with a medium that does not always fit nicely into existing rules. If Texas is too stringent in the application of regulations, it may be denying an equitable, high-quality education to many students. Texas may need to reconsider the entire regulatory structure rather than manipulate the delivery systems to fit existing standards. In *Technology and Transformation of Schools*, Lewis J. Perelman says, "unfortunately, when 'adoption' of innovation is equated with 'addition,' the quest for the *new* usually leads not to *better* educational systems, but only to the traditional demand for more staff, space, things, and money" (1987, p. 106).

Many question the right of states to dictate how individual schools and districts must carry out instruction. In Texas, teachers and schools have little input into the textbooks that will be used or what can be taught. Much literature exists on the subject of local autonomy for schools. A publication from the National School Public Relations Association suggests that "perhaps the best way to accomplish rural school improvement is to enhance the inherent strengths of rural schools rather than attempt to force them to fit outside structures" (Campbell, 1985, p. 3). Likewise, Allan F. Hershfield argues that, "The shift back to the local districts and individual school. . .is of fundamental importance to the quality and quantity of education which our students will receive from the schools. They deserve no less than our best efforts to reverse the trend toward state mandated curriculum to local control" (1986, p. 21). The traditional argument against a state-mandated curriculum is that state governing bodies are too far removed from the classroom to know what instructional needs students have. Under a mandated curriculum, teachers are unable to modify their instruction to incorporate topics that are of inherent interest to the student population. No room exists for variation -- all students in Texas must master the same curriculum, whether it is of use to them or not.

On the positive side, a statewide mandated curriculum provides continuity across grade levels, communicates needs to textbook publishers, gives teachers the ability to plan ahead, confirms the importance of subject areas through the process of mandated essential elements, and provides a statewide consistency for students who move around the state (TEA, March 1987b, p. 9). The State Board of Education requires that districts offer a minimum number of courses in specified subject areas so that students can take the required curriculum. Each required course must be offered at least every other year, in accordance with state law.

Even though the curriculum is mandated by the state, many districts are not in compliance. A TEA analysis of course enrollments for 1985-86 and 1986-87 indicated no enrollment during this two-year period in many districts in several core academic courses (TEA, December 1988, p. 24-27). Why are schools guilty of noncompliance? An important reason includes lack of resources and certified teachers. Instructional satellite courses can offer a viable solution to this problem.

Working within the Existing Structure

Given that educational reforms and innovations must evolve from the present system, the remainder of this section identifies important questions that must be addressed in developing distance learning practices that are effective and legal.

Teacher certification issues can restrict the use of telecommunication systems. State standards for certification usually are very stringent . The traditional classroom unit is perpetuated because funding regulations require that a certified person be present in the class (Bradford, 1980, p. 11). If a teacher is viewed in more than one state, must he/she be certified in each state in which the course is broadcast? A broadcasting teacher may not be certified even if highly qualified. If a broadcast teacher is well qualified but not state certified, states are doing a disservice to their students if that teacher cannot broadcast a course. Many states have similar certification requirements for teachers and must be willing to allow some flexibility in such decisions.

To ensure that teachers are highly qualified, Texas should seriously consider the recommendations of the Carnegie Report, *A Nation Prepared: Teachers for the 21st Century*, that called for the creation of a National Board for Professional Teaching Standards to authorize national certification (1986, p. 62). The issue of a national board for certification is especially relevant to Texas. Teachers who are nationally certified could be used as broadcasting instructors for distance learning courses, even if the course is taught out-of-state. The National Board for Professional Teaching Standards subsequently was established by the Carnegie Corporation, with the majority of the board composed of practicing classroom teachers. The objective is to upgrade the standards and quality of teachers in this country. Many states have expressed keen interest in the concept. Board certification raises the question of whether state licensing of teachers eventually will be unnecessary, since the national board will have tougher standards for certification than those set by states (Tucker, February 8, 1988).

Beyond the issue of certification, who will be responsible for evaluating the delivering teacher? Obviously, the distance learning project must accept responsibility for hiring good teachers. In addition, remote sites may need to have some input into the evaluation process. Evaluation procedures should be established when the course is accepted by a school district.

Teachers involved in the delivery of distance education, especially through telecommunications, must be trained to use the equipment properly. Of course, as Batey and Cowell said, "Good teaching is good teaching, whether the teacher and learner are in close proximity or at a great distance from each other" (1986, p. 16); nevertheless, teachers unfamiliar with the technology will need training in its use. They will teach lessons planned and developed by others, will need to prepare detailed lessons in advance, will teach without a group of responsive students, will teach with new types of feedback or none at all, will organize and structure materials in new ways, and will operate new technology. Staff may resist the technology due to computer illiteracy and apprehension about computers, lack of personnel needed to train others, staff resistance to procedural training, or unrealistic expectations of technologies (Helge, 1983, p. 11). Distance learning programs can be threatening to teachers at the remote site who are worried about job security. If programs are properly planned and implemented, distance learning need not be intimidating. Teachers at the local site play a crucial role in the classroom. Those supervising instruction will have to use plans and materials designed by others, keep to a schedule developed by someone else, help students focus on different stimuli, teach students to use new equipment, and learn to schedule repairs and maintenance (Batey and Cowell, 1986, p. 17). Obviously, teachers will need additional training to competently deal with these new requirements. For distance education programs to be successful, they must gain the support of teachers and their unions and professional associations (Martin, 1987, p. 10).

Student support is also important in making technology effective in schools. Although the self-motivated, task-oriented, well-organized, and independent student will excel in this atmosphere, all students can benefit from the implementation of technology. While the novelty of the approach will initially increase motivation and performance, most students need more long-term support. Distance delivery is not as personal as the traditional face-to-face method, but alternative methods can supplement communication between pupil and teacher, including written letters or journals, voice letters on cassette, telephone calls, group scrapbooks, peer tutoring, electronic mail, and special recognition for schools, classes, or students (McCormick and McCormick, 1982b, p. 17).

For telecommunications to become a viable option for school districts, courses must gain state approval. Standards used in the approval process need to be revised to take into account new types of programs. For example, classroom size restrictions may need to be altered to fit the new format. If a class must learn via television, the class size must be small enough to permit each student to be able to clearly view the screen. In addition, students around the country may be participating in the same instruction at the same time. For the telecommunications program to remain effective, the nationwide class size may need to be restricted. An interactive system must be able to be utilized by each student. If the broadcasting class is too large, students will not receive enough feedback from the delivering teacher. The delivery of a class presentation is very different via television. When states and districts are adopting distance learning programs, they should assure that the projects incorporate the following: the utilization of objectives for each lesson; preparation of the entire course in detail prior to the first class meeting; and alternatives to remedy the diminished amount of feedback and classroom dialogue expected in distance education settings compared to traditional face-to-face classroom environments (Haughey, 1983, p. 5-6).

State funding and other benefits are usually determined by the number of students attending courses at each school. If programs are broadcast from one district to another, the state must decide which district gets credit for the students who attend the television course. States cannot allow one school district to raid another by offering distance courses to the second district's students (Batey and Cowell, 1986, p. 21). Standard attendance criteria and perhaps even school district tax bases can be affected radically by nontraditional instructional delivery systems (Downing, 1984, p. 27).

Textbook standards that may be acceptable in one state may not be acceptable in another. States must decide if a teacher should be allowed to teach with materials not formally approved by that state. If a course is broadcast from one district to another district within the same state, teacher pay scales and benefit packages may differ. The districts must make salary arrangements as to which districts pays the broadcasting teacher's salary, and how all districts share in the cost.

Management and scheduling questions are issues in schools dealing with distance education. As the degree to which the new program differs from the normal events of a school district, school, or classroom increases the need for new management skills will increase. Administrators need to establish lines of responsibility for new technology, obtain and manage its funding, and learn new techniques of planning and recordkeeping. Schools need to organize plans to supervise students participating in the program, to obtain, manage, and maintain equipment, to schedule classes, to recruit and train new staff, to manage contracts and financial agreements, and to cooperate with educators in other districts. To adopt distance education, administrators need to conform to Federal Communication Commission (FCC) and other regulatory standards, gain state approval for new curricula and materials, and conduct public relations and publicity campaigns in the community (Batey and Cowell, 1986, pp. 21-23). Many of these tasks are new responsibilities for educators.

The development of high-quality curricula is another problem of distance learning. Many of the issues are traditional questions applicable to all curriculum development: Is the material comprehensible to students? Are instructions easy to follow? Are the goals and objectives stated clearly? Are materials and methods exciting and varied? Does the instruction meet needs of students and adjust for differences in abilities, desires, and interests? Is the course content accurate and up-to-date? Are the lessons well organized, clear, and concise? Do lessons guide students to alternate sources? Is the technology applied appropriate for content and learner? (Batey and Cowell, 1986, pp. 13-14).

A continuing question is whether lessons should be developed locally or purchased externally. Local development offers several advantages: lessons can be tailored to local interests, and local development fosters cooperative efforts and stimulates critical thinking by local staff. However, the quality may not be adequate, funding may not be sufficient, and elements of the lesson may be hard to obtain. Supporters of central course development by a professionally trained curriculum development staff claim that the product will be of better quality than that produced locally. However, nationally or regionally developed curricula is costly, may have problems obtaining accreditation, may be insensitive to local conditions, and may not accomplish local or state curricula goals (Batey and Cowell, 1986, p. 14). Perhaps the ideal is to develop national or regional curricula that can be easily supplemented by interested educators locally.

Program Costs

Costs are an important aspect to be considered. Satellites are not cheap and it is often up to the schools to pay for the equipment. Fred Williams, director of the Center for Communication, Technology, and Society at The University of Texas at Austin, sees a problem in that wealthier private schools and public school districts can be more innovative than poorly financed public schools, resulting in a serious disparity between advantaged and disadvantaged students (interview, October 1, 1987).

Ongoing costs are difficult to predict since the equipment being used is new and its useful life has yet to be determined (Helge, 1983, p. 10). Cost centers include the following:

Capital cost for hardware and equipment;
Development cost to put the system into operation;
Operating cost to run the program;
Marginal cost of adding user sites or students;
Expansion cost to enlarge the program;
Social cost: of the time and energy and staff needed to implement the program.

Costs should be calculated on a cost-per-student basis -- not just total cost. A program that costs $15,000 is more efficient if it serves more students. In addition, aspects of financing such as funding through third-party intermediaries and whether to treat fees the same as textbooks or as a service need to be addressed (Goldstein, 1984, p. 12).

Funding for programs must be long term, providing a stable source of support. Unstable funding can lead to a waste of money and time by implementing programs that can't be carried through to their completion (Batey and Cowell, 1986, p. 25). In many cases, grants may have to be provided to a district for initial set-up costs.

The cost of instructional satellite systems involves both equipment purchase and annual subscription fees. Required equipment for the Utah, OSU, and TI-IN networks includes a "downlink" or satellite receiving dish and a TV monitor. In addition, the OSU and Utah networks require one microcomputer for every two students enrolled in the systems (Barker, 1987, p. 5). The TI-IN network provides an example of these costs. First-year costs for the purchase of equipment and subscription to the network are $15,000. Thereafter, the annual fee is based on the number of students per school. Each block of nine students requires a fee of $3,750. Fees for in-service training, staff development, and test reviews are additional costs (Barker, 1986, p. 4).

After the basic equipment is purchased, the annual fees are usually low enough to make the programs cost effective for the district, especially when hiring qualified teachers is the alternative. If capital costs can be funded, consortia of small schools have demonstrated that they can successfully operate two-way interactive programs (in which both the video and audio components are two-way). Minnesota, New York, Wisconsin, Iowa, and Illinois are using two-way interactive television programs. Normally, between five and eight districts have formed the telecommunications network. Equipment for the two-way video/two-way audio systems is very expensive. For members of a cooperative, the total equipment cost ranges from $400,000 to $2 million, a part of which usually has been offset by sizeable grants from federal or state government, or the private sector (Barker, 1987, pp. 5-6).

CONSEQUENCES OF PRESENTATION AND DELIVERY

There have been few formal evaluations of satellite programs (Eiserman, 1985, p. 16). Of those conducted, many are inconclusive and/or have not gathered data in a disciplined way. Decisions about whether to continue an experimental project should be made with the assistance of an evaluation, which should include an assessment of the needs of the school district, a determination of the effectiveness of the program, an evaluation of the project's components, and a judgment of its worth by operating staff (Batey and Cowell, 1986, pp. 27-28). Care should be taken to avoid judging rural schools by urban criteria; urging rural schools to adopt models proven successful in urban settings may be counterproductive (Sher, 1981, p. 17). A real need exists to evaluate programs so that ineffective practices can be improved or discarded and effective ones can be utilized. This section summarizes evaluations of the programs by students and teachers and provides a review of program evaluations.

Students

Most evaluations of distance education programs at the K-12 level show that students like distance programs as much as they like conventional programs (Batey and Cowell, 1986, p. 27). However, a survey by Bruce Barker of TI-IN users revealed that 70 percent of students questioned would prefer a regular class setting if the opportunity were available (1986, p. 7).

The novelty of the instruction medium initially increases motivation and improves performance. But it can be difficult to sustain the motivation level without direct, face-to-face contact. Students may find it harder to concentrate with distance instruction and may need more breaks during the period. Ways to overcome the lack of direct communication include telephone contact, training of aides for support and help within the classroom, peer tutoring systems, and materials for parents to assist their children (Batey and Cowell, 1986, p. 22-23). An Illinois evaluation found that students feel that the talk-back feature allowed them to participate at least as effectively in the satellite class as in regular classes (Robinson and West, 1987, p. 8). A format for interaction during broadcast should be worked out to involve student callers naturally and comfortably. However, random calling throughout the lesson does not work well for interactive programming (Greece Central School District and Wheatland-Chili Central School District, 1987, p. 4).

The programs are most effective with students who work well independently, are self-disciplined and well motivated, and score in the above average range for most of their courses (Greece Central School District and Wheatland-Chili Central School District, 1987, p. 11). This is the audience that should be targeted for distance-learning projects. Bruce Barker's questionnaire to high school principals revealed that 80 percent of those questioned limited enrollment in TI-IN programs to *A* and *B* students (1987, p. 10). Students experiencing academic difficulty find that instruction through interactive television exacerbates their difficulties. They indicate that it is often hard to get questions answered or keep up with content (Morehouse, Hoaglund and Schmidt, 1987, p. 5). Not all students benefit from a telecommunications course. Students need to fully understand the medium of course instruction and what is expected of them before they enroll in satellite courses.

Evidence to date indicates that students learn as much through distance education programs as they do through conventional programs (Batey and Cowell, 1986, p. 27). For example, in a pilot test of the OSU satellite network German course, the 6th-12th grade students tested achieved scores equivalent to those of OSU students in a traditional setting (Hobbs, 1985, p. 24).

Students claim that distance courses make them feel more mature and responsible for their education (Batey and Cowell, 1986, p. 13). However, teachers report that cheating by students at the remote site is a problem. A Minnesota evaluation found that nearly half of the participating teachers believe that there are more discipline problems in satellite-instructed courses than in traditional ones (Morehouse, Hoaglund and Schmidt, 1987. p. 7).

Teachers

The quality of the broadcast content is determined primarily by the skill and style of the telecast teacher (Greece Central School District and Wheatland-Chili Central School District, 1987, p. 6). If teachers are poorly prepared or do not portray themselves well over TV, the program loses its effectiveness. Telecast teachers must be able to adapt to new methods and restrictions. Lesson plans may be partly or completely developed by others. Very detailed lessons must be prepared well in advance of delivery. Lessons must be presented according to strict and inflexible time schedules (Batey and Cowell, 1986, p. 21). Feedback from students is restricted, interactions are more student-controlled, and student understanding is more difficult to gauge because there is no direct contact. Presentation modes are limited; the delivering teacher cannot engage the students as can primary speakers in a discussion (Haughey, 1983, pp. 9-10).

Classroom teachers/managers at the local site also must be able to adapt to new methods. Lesson plans, materials, and teaching methods are devised mainly by others; the classroom teacher has little control. Course material is often totally unfamiliar. The pace of the class is predetermined and the classroom teacher can do little to alter it (Batey and Cowell 1986, p. 21).

Classroom teachers/managers at the local site who are certified teachers tend to be resistant to the distance learning programs because their role in instruction is diminished. Certification of local classroom teachers/managers may not always be necessary. They serve primarily as classroom managers rather than as instructors. A study in Utah by Kenneth L. Neal, coordinator of informational technologies for the Utah Office of Education, found no significant difference in performance of students in Spanish whether the classroom manager was certified or not or whether or not they could speak Spanish (Neal, p. 2). Distance programs may revolutionize the role of the teacher. Such issues as mandatory courses for distance teaching certification and separate certification for distance teaching may need to be addressed in the future.

In-service training should be provided to teachers to ensure success of the distance learning program. In a survey of principals using the OSU network, 80 percent felt that in-service training for administration was essential and 97 percent felt that the local classroom teacher/ managers should receive in-service training (Barker, 1986b, p. 5).

In many distance learning projects, teachers have been left out of the courseware development process (Downing, 1984, p. 28). To help guarantee the success of a program, experienced teachers should be included in its design and implementation.

Programs

Programs that incorporate multimedia delivery systems are more likely to be effective than programs with only one type of delivery (Batey and Cowell, 1986, p. 15). Distance learning programs often have unexpected results, including increased parental involvement with courses, increased cooperation and communication between schools and districts, and mastery of a technology which students and teachers can apply to other areas (Batey, 1986, p. 16).

Scheduling conflicts for broadcasting are among the biggest obstacles that distance learning programs have to work out. Broadcasters have a difficult time achieving full participation because not all remote sites share the same class time schedule. Students resent breaking off classes and the shortened class periods (Robinson and West, 1987, p. 13)

Equipment at the receiving site must be kept in good repair so that students do not fall behind because of faulty equipment. Minnesota teachers have recommended that procedures be developed for conducting class in the event of technical failure. Supervisory responsibilities can change when the system is down, and instructional time can be salvaged if a good procedure is adopted (East Central Minnesota Educational Cable Cooperative, n.d., p. 4).

New York's TI-IN evaluation found that larger sites (ADA larger than 1000) report more difficulty using the system fully, making the system cost-effective, and utilizing the interactive components of the system (Greece Central School District and Wheatland-Chili Central School District, 1987, p. 11). This finding may have future implications regarding the ability of districts to utilize distance learning projects in their large schools.

The total number of students in TV class should be limited to a size that offers the best viewing ability. An evaluation report of the Carrol Instructional Television Consortium, which uses two-way audio and video broadcasting, found that 12 remote students at one site is all the camera can broadcast clearly. At the originating site, 15 students can be taught, but televised class enrollment should be kept to under 20 (Robinson and West, 1987, p. 15).

Turnaround time on reviewing student papers can be slow if students' work is sent to the network for grading. One possibility is to provide the classroom facilitator with answer keys for some or all of the tests and quizzes to allow direct grading at the remote site. In Barker's survey of principals using the OSU project, 53 percent altered the grading scale used by the telecast instructor to accommodate the local conditions and policies of the school (Barker, 1986b, p. 9).

A question remains as to whether taped instruction can be as effective as live interactive instruction. According to Robert Ives, project director for the Utah network, post-test research has shown no difference in learning benefits between students with live instruction and a test group that learned via taped instruction. However, this finding may not be conclusive evidence. A paper by Bruce Barker (1986a) contends the opposite--that researchers have found that teacher/student feedback is needed for good instruction. Also, he criticizes the Utah network for using satellite technology to deliver videotaped sessions. Delivering the videotapes directly to each school would be much less expensive (1986a, p. 10).

INNOVATIONS IN OTHER STATES

A variety of sources, including universities, commercial producers, and various consortia have developed materials for distance learning courses (Downing, 1984, p. 26). In several states, the state department of education is taking the leadership role in the planning, implementation, and funding of distance learning projects. Yet, many satellite instruction projects are still in the infancy stage and states have not addressed important policy issues. The distance education programs in several states are summarized in this section.

Alaska

Before the 1986 oil crash, Alaska's telecommunications program was the most advanced and extensive in the country. More than 150 small communities were serviced by the Learn Alaska Network. The state of Alaska invested approximately $30 million into the startup of the network. In 1982, the University of Alaska created the University of Alaska Instructional Telecommunications Consortium to operate the system on behalf of the state Department of Education (Hershfield, 1986, pp. 1-2). Most of the programming involved one-way instruction. Since 1987, however, under pressure because of the state's financial problems, the Alaska system had become almost nonexistent. Alaska demonstrated two key ingredients to successful implementation of distance learning delivery systems. The state's Department of Education took a major leadership role in the planning, implementation, and maintenance of the programs, addressing issues such as formula funding, teacher certification, and state accreditation (Downing, 1984, p. 27). However, at least one researcher concluded that, aside from financial reasons, the network was doomed to fail because it was created for an audience of about 30,000 native Alaskans scattered throughout the state, a population too small to justify such a sophisticated instructional system. Also, the state provided only $200,000 annually to finance the system, an amount too small to permit the acquisition of much original programming. The network had to obtain most of its programs from other states. As a result, the course material provided little of relevance to native Alaskans (Hershfield, 1986, p. 3).

The Learn Alaska Network is "a classic example of the consequences of focusing on telecommunications technology almost as an end unto itself rather than as a means to serve a particular client group" (Hershfield, 1986, p. 3). In May 1988, Alaska Department of Education officials began talks with Canadian officials to revive its satellite learning programs on a joint-venture basis.

Arkansas

In March 1987 the Arkansas State Board of Education approved guidelines to assist the Department of Education to implement satellite instruction. All programs are under the supervision of the Department of Education, and satellite courses must adhere to the course objectives established by or approved by the Department of Education. Arkansas requires that the satellite courses be taught by experienced master teachers; classroom managers should be certified, preferably in a related subject field. In exceptional cases, Arkansas allows a trained aide to serve as supervisor. Classroom managers must be provided with in-service training. Also, textbooks must be selected from the state-approved list, and enrollment must adhere to Department of Education class-size guidelines. Arkansas requires that credit for a satellite course in mandatory subjects can only be awarded if a school district is unable to provide a certified teacher for the course. In addition, satellite course credits are limited to three units in accordance with graduation requirements. Districts which are designated as isolated may request permission from the Department of Education to offer a fourth unit of credit.

Arkansas is presently using the Utah and OSU networks. According to State Board member John Fortenberry, approval of the telecourses includes the use of the networks' broadcasting teachers (Telephone interview, October 19, 1987). Both programs correlate fairly closely with curriculum guidelines. If a satellite course does not correlate, a supervisor in the corresponding area of the Department of Education can supplement the course with additional materials. Grading styles are different for the two systems. OSU provides the classroom manager with an answer key, and the schools do their own grading. In the Utah project, materials are mailed to Utah to be graded, reducing paperwork for the remote site instructor but also creating slow response time. The cost of these projects can be easily justified because of the relative expense of hiring teachers. Once the downlink, computers, and VCRs were installed, the cost of each program was reduced drastically.

Georgia

According to Max Wilson, consultant on technology for the Georgia Department of Education, Georgia does not have any type of guidelines to address policy issues associated with interactive satellite television (telephone interview, November 24, 1987). Presently, Georgia receives television broadcasts through the Georgia Public Network System, which offers curriculum enhancement. In addition, the Atlanta School District is experimenting with Utah's satellite program to teach Spanish in middle schools. Because the program is exploratory, the school district did not have to go through the Department of Education. According to Blanche Hamilton, coordinator of foreign languages for the Atlanta School District, only four of the fifty teachers serving as class managers for the program are certified language teachers (telephone interview, October 27, 1987). The others are certified in other fields. Hamilton feels the program has been a success. However, she has encountered resistance from the participating teachers who are uncomfortable with the instructional method. Teachers do not like to monitor a class in which they have little knowledge of the subject taught through the satellite program. She has had to incorporate several in-service training periods for them.

Hamilton cross-checked the skills taught in the course with Georgia's minimum standards; they correlated acceptably. Georgia has strict rules concerning class size. Satellite course enrollment is kept within the 24-pupil limit. The program has been cost effective for Atlanta, especially since the total enrollment is 4,500 students. Without the program, the school district would have to hire thirty language teachers. The initial cost for installation of the program equaled the salary of only two teachers, and the equipment can be used from year to year. If the Utah project is to be incorporated into the curriculum on a permanent basis and used in the high schools, the Department of Education will have to examine closely the implications for Georgia's traditional standards.

Minnesota

In Minnesota, approximately 50 districts are involved in a live two-way video and audio project called the Technology Demonstration Program. A teacher is present at one of the several participating district schools, and may or may not be instructing a class at the original site during broadcast. Cameras are normally stationed at the original and remote classroom sites; so the teacher may see students at each of the sites, and students may see other students at the other sites (Morehouse, Hoaglund, and Schmidt, 1987, p. 1).

In 1984, the Minnesota State Board of Education ruled that the program should offer many subjects that had low enrollment and were not offered in most of the small high schools. There is a high level of interest in the state to utilize interactive television for the teaching/learning process (TDS Minnesota et al., 1985, p. 25). Districts working together have had to relinquish a degree of local autonomy because of agreements that must be reached on school calendars, course and grading requirements, daily schedules, registration processes, and prerequisites for student admission (Morehouse, Hoaglund and Schmidt, 1987, p. 4). Minnesota has adopted a policy that requires participating schools to adopt the course materials, the school calendar, and the grading system of the course's originating district . The remote site district must agree to provide classroom supervision by licensed teachers, but their only responsibility is for behavioral supervision of the remote site students. The telecast teacher is responsible for the course content, instruction, testing and evaluation, and all other necessary student instructional responsibilities at all remote sites. Broadcasting teachers must be paid at the highest salary of any district in which they teach. All teacher evaluations must be conducted by trained evaluators at the origination site. No evaluation can be conducted by electronic means. Remote class size cannot exceed 20 students per teacher for grades 7-12 (TDS Minnesota et al, 1985, pp. 47-49).

Missouri

The Missouri State School Boards Association (MSSBA) has played the main leadership role in the innovation and implementation of telecommunications projects in Missouri. The MSSBA has established the Educational Satellite Network, which broadcasts a full range of programming, including high-school courses, student enrichment programs, staff development programs, and classes for college credit statewide. According to Hal Gardner, member of the MSSBA, the Missouri State Board of Education has recently approved the satellite course guidelines, which were proposed by the MSSBA (Telephone interview, February 17, 1988). The rules state that classroom teachers must hold a valid Missouri teaching certificate for the grade levels at which the course is offered and that they have completed academic preparation as determined by the department. The classroom instructor does not need to be certified in the broadcast subject. In-service training must be made available by the sponsor of the telecommunications course. Other rules include clearly stated outcomes or objectives for learning, proof of the effectiveness of the program, and high standards of quality in production and presentation. Once the course has been approved by the Department of Education, the user district continuously monitors and evaluates the effectiveness of the course.

New York

New York, one of the leading states in developing satellite programs, plans to uphold its traditional course guidelines for satellite courses. Any teacher that instructs through telecommunications must be certified by New York. Out-of-state teachers have been cross-certified so they can teach in New York's system. The state is not planning to adopt any out-of-state programs; it will rely on its own capabilities. However, the TI-IN network has been pilot tested in New York with favorable results. In order to tailor TI-IN courses to New York State curriculum and certification, New York has established a TI-IN satellite uplink capacity within the state (Greece Central School District and Wheatland-Chili Central School District, 1987, p. 4).

Oklahoma

Oklahoma is one of the handful of states that has a written set of satellite instruction regulations. The regulations were prepared by the Oklahoma State Department of Education (SDE). Each program used in Oklahoma must submit an application for broadcast in the state and must be approved by the SDE. To be approved, the course content must correlate with the Oklahoma suggested learner outcomes. To qualify, satellite courses offered for high-school credit must use textbooks selected from the Oklahoma approved list of textbooks. Each classroom teacher must be certified for the grade level that he/she is supervising but does not need to be certified in the course subject area. Instead, the satellite classroom instructor receives in-service training pertaining to the course organization, classroom management, and technical aspects. The television teacher does not have to be certified in Oklahoma. In fact, many of the instructors used for broadcasts are university professors. Enrollment in these courses is only restricted by the traditional State Department of Education class size regulation, which varies with the course being taught. Although the application asks for a plan for student evaluation, the regulations state that the local education agency is responsible for establishing specific uniform procedures for evaluating student progress and assigning a course grade. Sandy Garrett, director of rural education, stated that new regulations need to be developed because Oklahoma is experimenting with two-way interactive television, in which a local teacher may not have to be present in the classroom (telephone interview, November 20, 1987).

Other States

The states initiating the more progressive satellite projects are discussed above. South Carolina has implemented an instructional television network but is not working with interactive or taped satellite programming. At this point, South Carolina considers the costs of employing a satellite service to be prohibitive (South Carolina Educational Television Network, n. d., p. 16).

The California State Board of Education has not adopted any definitive guidelines to deal with satellite instruction, although several state colleges are broadcasting courses into the high schools. Also, TI-IN is being used for advanced-placement classes, but Dr. Frank Wallace, educational technology consultant for the Department of Education, believes that California will use its own state programs once it has uplinking capabilities (telephone interview, November 24, 1987).

In midwestern states such as Colorado, Illinois, and Iowa, control over policy is usually at the local level. Districts decide on their own textbook requirements. None of these states have established any overall guidelines or policy to deal with curriculum or certification issues. All have pilot programs for distance education underway. For example, Iowa is presently experimenting with TI-IN programs and has ruled that a certified teacher must be present in the classroom. According to Alan Gnosphelias, national sales director of TI-IN, Iowa has required that the broadcast teacher also be an Iowa-certified teacher, which imposes severe limitations on the state's use of any national satellite programs.

Region 20 Educational Service Center in San Antonio, Texas, provides the broadcast facility and uplink, develops the lesson plans, and selects the certified high school teachers for TI-IN. The lessons are submitted to the Texas Education Agency for approval and accreditation (Batey and Cowell, 1986, p. 12). Gnosphelias expressed some of the concerns of states that use the network (Telephone interview, November 24, 1987). Some states, such as Iowa, Wyoming, and California, require that each teacher broadcast into their state be certified for their respective state. TI-IN is beginning to certify teachers for certain states. Some states, such as Ohio, do not care if teachers are state certified. TI-IN looks for highly qualified teachers, normally requiring that they have their masters degrees. Presently, TI-IN is broadcast in 25 states at 312 sites, mainly rural.

Gnosphelias believes that state departments will not be able to restrict TI-IN from use in states with certification requirements because rural school districts will apply too much pressure to utilize the courses. Although most states have curriculum guidelines, these have not caused too many problems because of the nature of the courses being broadcast. TI-IN offers only high-level courses such as Trigonometry and Calculus in which the requirements are normally uniform throughout the country. TI-IN uses textbooks adopted in Texas, which has some of the most stringent standards in the country. These textbooks are normally acceptable for other states' requirements. Many classes average 10 students, some with as few as one or two. Because TI-IN restricts enrollment of a nationwide class to 200 and TI-IN classes tends to have low enrollments, states have not had to adopt special class-size restrictions.

CURRENT TEXAS POLICY

Of the states investigated, Texas has developed the most stringent standards for telecommunications program adoption. Two Texas Education Agency publications, *Guide to Distance Learning as an Alternative Delivery Procedure* (March 1987b) and *Distance Learning Proposal* (March 1987a), describe the procedures adopted by the Texas Education Agency (TEA) and the Texas State Board of Education and outline the information that broadcasting agencies must provide.

Private agents must be cosponsored by an accredited public school agency or other approved entity before a plan for a telecommunications course will be approved by TEA. Once TEA approves the program, it can be used in the school district. User districts and the delivery system operator are responsible for working out such details as development of schedules for exams, enrollment procedures, and other arrangements. Courses must be comparable in quality to on-site classroom courses taught by local teachers. TEA requires that the course being taught by telecommunications must be a certified course for high-school graduation. In addition, the broadcasting agency must ensure that the course includes all essential elements as prescribed by the state unless it is a course approved by TEA as an experimental/magnet program course, a correspondence course, an honors course, or a high-school course for college credit.

The proposal from the agency must include detailed descriptions of courses; the agency's procedures and criteria for faculty selection for distance learning course instruction; student factors, including designs for feedback and student evaluation; self-evaluation design that is used by the agency; and its annual operating reports. TEA allows waivers, permitting larger class sizes than on-site managed instruction as long as the school and/or agency delivering the course can ensure quality instructional management for each student or assign additional staff. Also, telecast teachers do not necessarily have to be certified by Texas. Materials such as textbooks, workbooks, and audiovisuals are reviewed by TEA for approval.

TEA requires each distance learning program to conduct an institutional self study of its instructional program the first year of use and once every three years thereafter. Additionally, distance learning programs are monitored and evaluated at least once every five years by TEA. Plans are reviewed and approved or negotiated until approved or denied, based on the criteria and judgment of the commissioner of education.

CONCLUSIONS

This chapter focused on distance learning alternatives to the traditional mode of instruction available to rural schools. Through the use of distance learning, rural schools with limited resources can offer additional curriculum and provide better instruction, while avoiding the hardship and inconvenience of school district consolidations. The development of distance learning in rural schools offers the promise of a better education for many who have been denied it in the past. Texas should encourage and support distance education for rural areas across the state, and should consider resources allocated for distance education as an investment for the future.

Various types of distance education include the use of electronic mail, the telephone, videotext, and audio teleconferencing. Perhaps the most exciting innovations in delivery systems have occurred with the use of satellite programs and interactive television. In the past few years, Oklahoma State University, Utah State University, Eastern Washington University, TI-IN, and the state of Minnesota all have developed satellite networks that have changed the manner in which many students in rural areas are receiving instruction. In addition to Minnesota, states presently experimenting with distance learning programs via satellite include Oklahoma, Arkansas, Missouri, New York, Alaska, California, and Texas.

Evaluations of satellite programs generally have shown favorable results in students' learning, but not for all students. Students who are self-motivated tend to perform better than those less motivated. Many students need more feedback from the instructor than distance learning systems are able to provide. Schools need to target appropriate student populations for distance learning projects if they expect to achieve success. On-site teachers play a major role in assuring that satellite classes operate smoothly. Texas must carefully determine the qualifications it expects of both the broadcasting teachers and the classroom monitors. Also, the state should evaluate programs to discover which types of format for delivery are most effective and identify aspects that can create problems.

Specific concerns that Texas must reconcile as it adopts distance learning programs include state restrictions on teacher certification, classroom size, textbook requirements, and curriculum guidelines. Satellite instruction can enhance education in Texas, provided that stringent guidelines do not create obstacles. Michael Goldstein, author of "Issues of Law and Policy Affecting Telecommunications-Based Distance Learning," says,

> An entity that obtains a package of instructional programs and acquires . . .the means of disseminating it to a dispersed learner population may bear no resemblance whatsoever to a traditional educational institution. To attempt to apply existing standards for the approval of an elementary or secondary school to such a provider of educational services may be impossible (1984, p. 21).

Future policies must be flexible enough to address the changes that modern technologies create. Given the unique nature of instructional delivery through distance learning, Texas may need to make accommodations in its regulations. Its current policy of allowing class-size waivers and permitting qualified -- but non-Texas certified -- broadcasting instructors exemplifies the accommodation that Texas should be promoting. Yet, if the state wants to make distance learning effective, it may need to streamline its rigid application process for out-of-state vendors and to find ways to relax its qualification that all essential elements from the curriculum be included in the instruction -- without undermining the objectives that the system of universal essential elements aims to accomplish. School districts should be allowed more autonomy to decide which kind of delivery system is best for their students and which vendors they wish to employ.

Now is the time to begin experimenting with new educational strategies that include the uses of technology. The National Governors' Association's *Report of the Task Force on Technology* recommends that states encourage and assist school districts willing to try out new ways of restructuring school environments through the use of educational technology. The report also recommends that states cooperate with one another to create consortia and other technical assistance arrangements to save time and resources (1986b, pp. 132-133). Texas should work closely with states such as Missouri, which has developed its own statewide satellite network, and Minnesota, which has pioneered its live two-way video and audio project. Close contact with other states, as well as a willingness to experiment with other states' successes, will ensure that Texas is providing the best education via innovative technologies.

Chapter 5. The Effects of Using Educational Technology on the Skill Requirements and Preparation of Teachers

How will the use of educational technology affect the skill requirements and preparation of teachers? There is no single answer to the question. Instead, the effects will depend on many factors, including how the technologies develop, the extent to which they are adopted, the nature of their uses, and the administrative arrangements that are devised to accommodate their capabilities. Also unresolved are possible changes in the teaching profession as a whole due to recent educational reforms, which at least in part have targeted the qualifications of teachers. This chapter presents background information to familiarize the reader with basic issues relevant to teaching and technology and summarizes findings regarding changes in skill requirements, teacher preparation, and in-service training. Finally, the teacher preparation/certification process in Texas, the current implementation of computer-based instruction in Texas schools, and recent legislation affecting teacher training in the state are discussed.

A review of the literature on technology and teaching yielded somewhat disappointing results. Considerable research has been conducted on the effects of technology on student achievement, but relatively little scholarly attention has been paid to changes in the role of the teacher due to a technology-intensive classroom. Concern over the lack of research was echoed in a recent conference involving teacher educators; Dean Carrier of the University of Minnesota College of Education noted that research in this area tended to be "anecdotal" rather than systematic. Much existing research is based either on outright conjecture or on limited surveys of technology use and teacher training programs. Little empirical work has been reported. There is widespread, speculative agreement that the role of the teacher will change but less agreement on the specific nature and extent of the change (Carrier, 1988, p. 1).

Yet teachers represent the crucial interface between the technology, the curriculum, and the students. In a very real sense, "the software is only as good as the teacher" (Urban Institute, 1986, p. 15). Teachers may be the primary determinants in the success or failure of a technological innovation in the classroom (Savenye, Cooper, and Spiegel, 1985, p. 12). By extension, the teacher is only as good as the training he or she receives. Any plan to make greater use of technology in the schools thus must include steps to ensure adequate teacher training, particularly since the costs of training may exceed the combined costs of hardware and courseware (Levin et al., 1987, p. 63).

The use of classroom technology may have differing effects on teachers of different subjects and student populations. To simplify discussion, this paper focuses on the applications of technology (primarily computers) in regular instruction, regardless of subject matter or the characteristics of unique student groups, since these matters are addressed elsewhere. The following discussion attempts to make clear the suppositions underlying the findings.

BACKGROUND

The 1980s have seen numerous educational reforms. Recent trends among the states include increased high school graduation requirements, increased instructional time, greater use of standardized tests, and stricter requirements for accountability by teachers and schools. Qualifications of teachers also have been a major focus of the reform efforts. By 1987, 35 states had raised preparation and certification requirements and another 14 states were considering such proposals ("How Not to Fix," 1987, p. 43).

Teaching

The current wave of reform has worked both for and against the concept of teacher autonomy. Several proposals have recommended decentralizing the administrative structure of schools to restore the freedom of teachers to make important decisions regarding curriculum and teaching methods, but most recent reforms have emphasized accountability over autonomy, mandating to teachers certain recordkeeping requirements, the precise content of courses, and the methods to be used in instruction. Accountability generally is enforced through elaborate appraisal instruments that minutely specify desired teacher behaviors. Apparently, society wants both accountability from and autonomy for its teachers but is unsure how to achieve them simultaneously.

A nationwide survey of teachers was recently conducted to determine their views of the reforms imposed since 1983. Collectively, teachers graded the reforms a *C*. The results indicated a general worsening in working conditions with regard to working space, teaching loads, class preparation time, class size, and freedom from nonteaching duties (Carnegie Foundation for the Advancement of Teaching, May 1988). According to the Ernest Boyer, president of the Carnegie Foundation and author of the report: "What the data show is that teachers feel largely bypassed in the process. Regulations have added more paper work, and the bureaucracy has increased. Teaching conditions have gotten worse. And in the process, morale has gone down." (Carnegie Foundation for the Advancement of Teaching, May 1988).

A prerequisite for improving American schooling is reorganization of the educational system in a way that gives individual teachers flexibility and rewards them for innovative, successful practices (Tucker and Mandel, 1986, p. 24; Murray, 1986, p. 29). At issue is the ability of current teachers and those now enrolled in schools of education to meet the demands called for by educational reformers. From the reformers' viewpoint, the problems are obvious: declining test scores for students entering schools of education, a declining number of students entering teacher education programs, and an incentive structure that fails to reward teachers based on their efforts and abilities. Many teachers approach performance appraisal plans with great skepticism because they do not believe that the plans can be administered fairly. Yet for most teachers, the skills required and the responsibilities assumed on their first day of work are the same as those they can expect to have years later. Teachers seeking more responsible and higher-salaried positions must become administrators or leave teaching. Both routes rob the classroom of its most capable instructors. As stated by Marc Tucker, former executive director of the Carnegie Task Force on Education and the Economy:

> . . . we reward time in the seat and the acquisition of graduate credit irrespective of whether anything is learned -- much less applied -- in a manner that is beneficial to children . . . because appropriate rewards are denied to the most skilled. Prevailing incentives drive many out of teaching but are sufficient to keep in teaching people who perceive themselves as having less appealing alternatives elsewhere (Tucker and Mandel, 1986, pp. 24-26).

In recognition of the need to differentiate between teachers of varied skills, many states tie pay raises to the number of hours of in-service training received, and a recent trend involves testing the basic skills of teachers. These criteria for determining selection for financial rewards are questionable on grounds of effect.. Requiring teachers to seek additional training to qualify for pay raises does not necessarily benefit students if the teachers are not then granted the autonomy to make decisions based on what they have learned. A test of basic skills, which all but a small fraction of the teachers pass, merely establishes a lowest common denominator and does not differentiate between teachers according to higher cognitive abilities or teaching skills.

The Carnegie Forum Task Force on Teaching as a Profession has recommended restructuring the administrative processes of schools to give teachers more freedom in the classroom as a means of attracting and retaining highly capable teachers. A primary recommendation of the forum is the establishment of a national standards board for teachers (Tucker and Mandel, 1986, p. 24). This board would be given the responsibility of designing and administering a national licensing exam for professional teachers. High standards for passage would enable the educational system to differentiate the most capable on an objective basis. Those licensed would have demonstrated the ability to assume decisionmaking roles, thus facilitating the other primary recommendation of the forum: decentralization of the decisionmaking process. The report addressed the autonomy-accountability issue directly and proposed a viable process for its resolution.

The basic goal of the Carnegie Forum is to further professionalize the practice of teaching. To do so requires greater adoption of the generally accepted attributes of professions. One such attribute is the systematic control of admittance into the profession by means of a standardized professional examination. A second attribute is a systematic and distinguishable body of knowledge which, once mastered, sets members of the profession apart. Other attributes resulting from demanding licensing standards are respect within the larger community, higher pay commensurate with increased responsibilities and expectations, and a collegial bond among members that fosters unity and incentive for the advancement of the profession and its goals.

The relative degree of autonomy exhibited by teachers influences how technology is applied in schools. The promised individualization of instruction due to technology confers great discretion and flexibility upon the teacher. In fact, increased teacher autonomy may be a necessary precondition for the effective use of educational technologies, especially during their experimental stages.

Technology

Defined broadly, *technology* is the use of knowledge, tools, and skills to solve practical problems and extend human capabilities. Especially important is the systematic application of scientific knowledge. One of the most powerful technology available to teachers today is the understanding of psychological and biological principles underlying human growth, development, and learning. All people do not learn at the same rates or in the same ways. The most effective teaching occurs when the instructor is able to track the progress of individual students, identifying both the areas of confusion and the teaching strategies that work for the individual student (U.S. Congress, Office of Technology Assessment, 1987, p. 249). In this context, the process of learning is as important as the lesson being taught. If education teaches the student how to learn, he or she will be much better prepared to enter a job market where the process of learning is becoming increasingly important. Current lecture-based instruction does not take this individuality into account. One study suggests that teachers move to a new topic when only 30 to 50 percent of the students have mastered only 80 percent of the material (U.S. Congress, Office of Technology Assessment, 1987, p. 250). A major justification for the use of computers and other educational technologies involves the transformation of traditional instruction into methods that account for individualized pace and learning style.

Promising developments in educational hardware include (1) telecommunications devices, such as satellites, optical transmissions, low-powered television, subscription (cable) television, and cellular mobile telephone; (2) recording and playback devices, such as video cassette recorders, videodisk machines, and compact disks; and (3) computing and artificial intelligence devices, such as microcomputers, minicomputers, local area networks, mainframes, and supercomputers (Williams, 1987, pp. 22-41). The media most commonly associated with the modern classroom are instructional television, the videocassette recorder, the microcomputer, and the interactive computer-based videodisk machine. Interactive computers can be integrated with classroom instruction in numerous ways, including drill and practice, simulations, tutorials, game playing, discovery and inquiry, and problem solving.

A recent report by the federal Office of Technology Assessment outlined the educational uses of new information technology:

- computers capable of tailoring packages of instruction to each student's interests and abilities, following each student's progress, and tailoring instruction to defects in each individual's understanding;

- advanced input/output devices capable of manipulating sounds and images as well as written words;

- communication systems capable of providing specialized training for people who may be learning in isolated regions or with highly specialized interests or needs; and

- communication strategies that permit greater exchange of ideas and teaching materials among teachers themselves (U.S. Congress, Office of Technology Assessment, 1987, pp. 12-22).

A national survey reported that $680 million were spent on computer hardware and software at the state level during 1985-1986. Forty-seven states intended to continue funding at the same or increased levels for 1986-1987 (Reinhold, October 1986, p. 27).

Interactive technology can be applied in the classroom in three ways: (1) incorporated into the existing curriculum, (2) used to enrich the current curriculum, and (3) introduced as a separate subject (Urban Institute, 1986, p. 9). Unfortunately, most states started with the third strategy, teaching computer literacy as a separate subject -- a practice that has been likened to teaching courses in the history and theory of the pencil (Tucker, February 9, 1988).

A more recent trend has shifted toward enrichment and integration into the existing curriculum; in other words, using computers as tools rather than as stand-alone subjects. Wisconsin, for example, rescinded its 1985 requirement that all students take a computer course. In its place is a mandate requiring that all primary and secondary schools use technology whenever appropriate in curriculum areas (Reinhold, 1986, p. 30).

Computer technology also may play an important role in the administration of the educational system. Through networking and data base management techniques, teachers can use computers to average grades, keep attendance records, prepare and print report cards, and print tests. All these tasks can be performed with relative ease and with greater efficiency using a computer than with manual processes. The result is to free the teacher's time for teaching (Urban Institute, 1986, p. 3).

Technology may be diffused through the schools either horizontally or vertically (Williams, 1987, p. 185). Horizontal diffusion of educational technology occurs when one or more teachers begin to use a technology and the practice then is emulated by other teachers. The problems associated with horizontal diffusion involve the efficient acquisition and coordination of resources. Vertical diffusion occurs when planning and implementation are performed by the administrative hierarchy. By contrast, vertical diffusion faces potentially serious problems of teacher acceptance. A debate exists over whether use of the technologies should be mandated from above or initiated by the teachers themselves. According to a recent study at Johns Hopkins University, decisions regarding the use of technology increasingly are being made higher in the administrative hierarchy (Urban Institute, 1986, p. 3).

SKILL REQUIREMENTS

Extensive literature exists on the effects of technology on the upgrading or downgrading of skill requirements for various occupations and professions. Aggregate studies of the effects of technology across job categories show little net change in skill requirements; however, case studies that focus on a single job category often show very large changes. Technology apparently upgrades some jobs while downgrading others and the net effects cancel out (Spenner, 1985, pp. 125-154). Based on existing research, it is difficult to predict the effects of technology on the skills required for teaching

Often overlooked in the skilling-deskilling controversy is the role of human choice in determining the outcomes. The effects of using technology on the skills required of teachers will depend at least in part on decisions by policymakers regarding adoption and implementation. Rightful concerns exist regarding the effects of overly homogenized instruction on students and the development of deskilled, "teacher-proof" systems on the teaching profession. Despite these concerns, most educators and theorists believe that future technologies can be designed to incorporate diverse humanistic objectives and that the increased use of classroom technologies will upgrade the skills required of teachers.

A basic premise of this chapter is that teachers in the future will need to possess all the skills currently required *in addition to* the new skills made necessary by technology. The role of the teacher in the classroom and in society has proven remarkably stable across the decades; technology alone seems unlikely to downgrade the role of teachers, nor will technology be the main determinant of teacher skill requirements.

Incorporating New Technologies into the Curriculum

Few explicit pedagogical models exist for teachers to emulate when trying to integrate technology with teaching. One immediate challenge for educators (both singly and collectively) is to fit new technologies into the broad context of learning theory -- to determine what works under different circumstances. Decisions regarding the adoption of technology are currently made primarily by the individual teacher. However, the ongoing process of previewing, selecting, and adapting the technologies for classroom use clearly is a task for the entire teaching profession. As the technologies evolve, and as consensus emerges regarding their best applications, the decisions will increasingly be made within the framework of an accepted theory -- one that matches the strengths and weaknesses of different technologies with specific educational objectives.

The selection of a teaching medium that is appropriate to the message has always been a responsibility of teachers. The new technologies highlight the need for teachers that have a broad understanding of learning processes as well as expertise in subject matter. According to one researcher, teachers will need to have "mastered the domains of their field" and to have an "awareness of the students' understandings and characteristic patterns of learning and perceiving" (Savenye, Cooper, and Spiegel, 1985, p. 1).

The role of the teacher varies with the general technological tools selected, whether telecommunications, recording and playback, or computing, as well as with combinations of technologies, such as computer-based interactive videodisks. The teacher's role varies further according to the specific application selected within any of these media. Table 1 illustrates the teacher's role under various forms of computer-based instruction. The roles presented imply that somewhat different skills are needed for each application.

Not all teachers subscribe to identical philosophies of teaching. Interestingly, a recent survey by the American Association of Colleges for Teacher Education (AACTE) found that teachers using a discovery approach (a method of teaching that encourages insight and self-discovery on the part of the student) reported the least change in their methods after adopting instructional technologies -- because the technologies "fit with their approach" (Carrier, 1988, p. 1).

Operating the Technologies

At the present time, simple computer drill and practice is the most common educational application of technology, but drill and practice also is the usage that "asks the least of the teacher to administer, that takes least advantage of the computer's peculiar capabilities, and that lends itself best to testing" (Urban Institute,1986, p. 1). It is probable that a trade-off will always exist between the technology's ease of use, its technical capabilities, and the changes in instruction required for its accommodation.

Applications more esoteric than drill and practice will undoubtedly require more extensive technical skills than are currently provided in basic computer literacy courses. In describing the role of the teacher in a classroom fully supported by a computer-based interactive video system, two researchers identified the following tasks:

1. set up equipment/systems
2. operate system equipment
3. select computer software
4. teach students how to operate computer-videodisk equipment
5. teach students about computer technology
6. teach students to use computers and videodisks as reference tools
7. perform simple equipment maintenance and troubleshooting
8. run system diagnosis
9. communicate with service technicians
10. demonstrate system to other teachers and parents
11. promote instructional technology use among other teachers
12. help other teachers in other disciplines adapt to technology
13. foster parent and community support for innovative programs. (Savenye and Hudspeth, 1985, p. 2).

Table 1

The Roles of the Teacher under Various Forms of Computer-Assisted Instruction (CAI)

CAI Mode	Roles of the Teacher
Drill and Practice	1. Arrange for prior instruction 2. Select material 3. Match drill to student 4. Check progress
Tutorial	1. Select material 2. Adapt instruction 3. Monitor
Gaming	1. Set limits 2. Direct process 3. Monitor results
Simulation	1. Introduce subject 2. Present background 3. Guide "debriefing"
Discovery/Inquiry	1. Present basic problem 2. Monitor student progress
Problem Solving	1. Assign problems 2. Check results

Source: R. Heinich, M. Molenda., and J.D. Russell. 1985. *Instructional Media and the New Technologies of Instruction* (2nd ed.). New York: John Wiley, p. 336.

Various other technical skills have been identified for teachers in classrooms that are fully supported by a computer-videodisk combination. Included are the teacher's operation of a master console that allows interface with any student's computer to monitor the student lesson, extensive use of an electronic mail feature, uploading student data by modem to district offices for central recordkeeping and reporting, processing summary data regarding individual and group progress, routine maintenance and troubleshooting, and using a "teacher-authoring" option, with which the teacher develops and programs specific lessons (Savenye and Hudspeth, 1985, p. 6).

A long-standing issue has been whether teachers will need to acquire skills in computer programming. The majority consensus of the 20 experts surveyed in the Urban Institute study was that relatively few teachers will need programming skills (Urban Institute, 1986). A similar finding was reported at the AACTE conference; in the future, as educational software improves, there will be less emphasis on teachers as programmers and greater emphasis on the comprehensive use of computers as tools (Carrier, 1988). However, even this finding implies computing skills that exceed most definitions of basic computer literacy.

Diagnosing Student Learning Problems

A comprehensive computer system that tracks student achievement also can generate meaningful data on possible barriers to student learning, thus enabling the teacher to pinpoint problems (for either the individual student or the class as a whole) and then to adapt his or her teaching methods as appropriate. In terms of skills, the teacher needs to know how to run the diagnostic program, draw inferences from the data, and determine an intervention strategy to overcome the barriers.

Whether a broad class of teachers could become truly skilled in diagnosis without forsaking other responsibilities is open to question. In a broad survey of computer use in U.S. schools, the diagnosis of learning disabilities was one of the advantages of technology use least often cited by teachers and principals (Savenye, Cooper, and Spiegel, 1985, p. 2). Another study indicated that when teachers received progress reports on individual students by class, subject, and objective, they tended to use group data rather than individual data, possibly because they did not always have the time to address the problems of individuals. Teachers did use individual data in assigning students to groups and in preparation for teacher-parent interviews, however (Savenye, Cooper, and Spiegel,1985, p. 4).

Individualizing Instruction: Managing the New Classroom

An often cited advantage of technology-based instruction is that it will result in teachers spending greater time with students as individuals (Savenye, Cooper, and Spiegel, 1985, p. 9). One approach to the difficulty of managing students at different levels of achievement is through computer-managed instruction (CMI). Without necessarily using the computer to deliver instruction directly, the CMI teacher uses the computer to diagnose the student's level of understanding, to match the student with available instructional materials, and to track the student's progress. Thus teachers will act as "enablers" of student learning. It follows that different skills will be needed under this system, as the teacher's role changes from being a direct transmitter of knowledge (through strict group management, rote training, and lecturing) to being a planner of individual lessons, a source of feedback and counseling for the student, a collector of teaching resources, a monitor of student progress, an adapter of lessons to individual learning styles, a facilitator of classroom time management, and a leader of group discussions.

These activities imply a more student-centered classroom, but it has been questioned whether teachers are comfortable with the low influence role inherent in a student-centered curriculum. Based on interviews of teachers in technology-intensive classrooms, one researcher concluded that teachers felt the need to be "editors" and "directors" rather than guides, tending to translate written instructions and turn discussions into lectures or recitations. He concluded that "how teachers construe their influence in the classroom has an important bearing on how particular innovative ideas will be adapted in use" (Savenye, Cooper, and Spiegel, 1985, p. 10).

Other general insights derived from experience with instructional technology are that teachers using telecommunications often cite heavier work loads and that teachers using high technology report the need to spend more time "keeping current" in their fields than those who teach using traditional methods (Savenye and Hudspeth, 1985, p. 16).

Teaching Higher-Order Skills

The extensive use of educational technologies may free the classroom teacher for higher-order tasks, such as

> coaching, diagnosing learning disabilities, developing students' creative and problem-solving capabilities, and participating in school management (Carnegie Forum Task Force on Teaching as a Profession, 1986, p. 94).

As direct factual instruction is increasingly delivered through computers, teachers will be asked to develop higher-order reasoning abilities in their students -- abilities such as logic, values, and problem solving, which are not assumed to be amenable to programmed instruction. Two related problems loom as a result of these observations. First, not a great deal is known about teaching higher-order skills, and second, even if a pedagogy develops for their instruction, it may prove difficult to appraise the teacher's efficacy in teaching them. A further problem is organizational in nature, namely, that higher-order skills are multidisciplinary by definition, yet the classrooms of today are organized by discrete content areas.

Specialization

In the long term, the use of technology in the classroom may result in specialization within the teaching profession. At present, the dictionary of occupational titles treats teachers as a homogeneous job category. In the future, teaching staffs could be divided into several specialties. *Tutors* trained in professional areas, such as chemistry or English literature, will work with individuals on a daily basis, coach them as they work through problems, monitor their progress in the programmed instructional systems, and challenge them to debate. *Specialized consultants* will work with students over a wide geographic area, handling questions or problems that individual tutors felt incompetent to address. *Specialists* will be needed *to prepare visual and audio materials for presentation* (that could include animation, simulations, or even complete reenactments of historical events) *and software* (that could include computer programming). *System monitors* will maintain order when students are working with information-based systems and to handle routine problems. *Staff to produce, maintain, and support hardware and communication modes* in the schools will be needed (U.S. Congress, Office of Technology Assessment, 1987, p. 409).

As technologies become better incorporated into the curriculum, new patterns of "faculty deployment" and instructional packaging may evolve to include greater use of team teaching, interdisciplinary studies, and instructional "modules," rather than entire courses (Savenye, Cooper, and Spiegel, 1985, p. 3).

PREPARATION AND TRAINING OF TEACHERS

Much has been said about the resistance of teachers to using the new technologies. Yet resistance may serve a useful purpose -- by forcing the advocates of educational technology to justify their claims. Some of the resistance has been well earned by those who overstate the capabilities of the new technologies. Several teachers have had unfortunate experiences in their efforts to use microcomputers when the software proved less friendly than expected. Some educators also may feel that the new technology poses a threat to their job security. Any effort toward its greater use in education thus must include some plan for reducing teachers' fears of the technological tools. Fears to be addressed through training include fears of uncertainty, of change, of technology, of machines that alter value systems, of machines that aspire to be human (especially because students sometimes prefer to work with the machines rather than the teacher), of visible accountability, and of changes in relations with students (Williams and Williams, 1985, pp. 87-95).

On the whole, however, the problem of resistance probably has been overestimated. Existing teachers most likely will use technology when more of it is available, when more complete training in its use is provided, when adequate incentives exist to encourage its use, and when its usage becomes more standardized (Frederick Williams, interview, October 1, 1988; Elgin Schilhab, telephone interview, September 24, 1987). At present, the introduction of technology into the classroom simply means additional work for the already burdened teacher, and few incentives are in place to encourage the transition to a more technology-intensive classroom. One study found that the teachers' enthusiasm for a computer-managed instruction system "was directly proportional to the amount of work done for them by the computer, and inversely related to the amount of new work levied on them" (Savenye, Cooper, and Spiegel, 1985, p. 4). The problem of resistance may resolve itself. Resistance diminishes with exposure. Teachers who receive training in technology are less resistant than those who have not had such training, and many students now entering education programs have had extensive familiarity with computers and other technologies.

A review of the status of technology training for teachers was recently performed under the auspices of AACTE (Carrier, 1988). The methodology included a review of the literature, requests for materials, and telephone interviews with state department of education officials, professional organization staff, and business/industry trainers. Their general questions and findings are summarized below, interspersed with findings from other sources.

What technology-related knowledge/skills/competencies are developed at the preservice and in-service levels?

AACTE reported that 10 of 15 schools of education reviewed have a computer literacy requirement for graduation, that one-third of all teachers surveyed have had ten or more hours of technology training, that many states are moving toward technology certification requirements, and that few data are available to suggest whether preservice graduates feel comfortable with technology. Educational institutions use varying approaches in teaching educational technology. At the University of Oregon, all education majors learn the basics of computer operation, word processing, data base management, spreadsheets, the integration of computers into the curriculum, and the uses of computers for testing. Students who plan to teach computer science at the high-school level or who plan to be computer coordinators at the high-school, district, or state levels, are offered a comprehensive interdisciplinary master's degree program administered by the school's computer science department. This program requires 36 hours of computer science courses. Students interested in teaching the use of computers or who want to be computer coordinators at the grade-school level are offered a master's degree program requiring 12 hours of computer science courses. This program is offered by the College of Education. The differences in the number of courses required for the two degree tracks is due to the different levels of skill required to use technology and to teach computer science (Dave Moursand, telephone interview, February 25, 1988).

Who delivers technology training?

"Everybody." Delivery sources identified by the review included colleges of education, school districts, regional service centers, professional organizations, and private corporations, including vendors of hardware and software. Two key problems were found to be unclear measures of training effectiveness and the absence of a central clearinghouse for information on training.

What roles do professional organizations play in technology training?

Most teachers' groups have released policy statements supporting the use of technology in education, but none have offered concrete guidelines regarding its implementation. Some of the organizations offer training and materials.

What formats and approaches are used to deliver technology training?

AACTE found that most schools of education start with technology as a separate course before (possibly) moving into more comprehensive approaches. Common in-service approaches included after-school workshops and summer institutes. Irregular follow-up to training was determined to be a problem, and it was emphasized that faculty need technology training before technology can be used effectively with students.

The experts interviewed by the Urban Institute generally agreed on the types of in-service training needed for the uses of educational technology. According to one, training should be handled in a three-tiered approach (Urban Institute, 1986, pp. 7-9). The first tier involves the minimum expertise needed to operate the technology. The second tier involves new educational skills: classroom management and the integration of technology into the curriculum. The third tier involves annual skill updates to allow for new developments. Two teachers from each school would receive intensive training at the tier two level. These teachers then would bring other teachers at their schools up to tier one immediately and up to the tier two over a longer period. The two teacher-trainers would receive yearly retraining to acquaint them with new developments (tier three) which they would pass on to their fellow teachers. By training two teachers at each school, the teachers would help each other develop ideas and facilitate the transfer of knowledge to other teachers.

What are the attributes of successful technology training?

Answers to this question were gleaned from studies conducted by the Educational Testing Service (Carrier, 1988). The following 12 practices contribute the most to effective technology training:

1. extensive practice with computers,
2. comfortable and relaxed atmosphere,
3. appropriate balance between lecture and guided practice,
4. individualized attention,
5. knowledgeable trainers,
6. detailed curriculum guides and lesson plans,
7. clear and relevant objectives,
8. lesson-related materials and handouts,
9. in-service lessons linked to instruction,
10. peer interaction,
11. voluntary participation, and
12. strategies for teaching heterogeneous classes.

On the basis of extensive interviews and a literature review, other authors have identified numerous topics relevant to staff development in microcomputers. These include operation of the microcomputer and peripherals, computer programming, selection and evaluation of courseware, modification of courseware, computer literacy, noninstructional uses of the microcomputer (e.g., management), integration of computer-based instruction into the curriculum, design and authoring of courseware, match of courseware with student abilities and learning styles, selection of hardware, computer-science curricula and teaching computer science, development of a user network, copyright protection issues, and instructional uses of microcomputers.

Incentives should be provided for teachers receiving technology training. Release time seemed to be the most valued incentive, followed by salary credits (Savenye, Cooper, and Spiegel, 1985, p. 13).

TEACHER PREPARATION, CERTIFICATION, AND TRAINING IN TEXAS

Policy Participants

The primary state education entity is the Texas Education Agency (TEA), created by the Gilmer-Aiken law of 1949. TEA has vast responsibilities in nearly all areas of state public education including textbook adoption, funding, and data collection and analysis. The agency also is charged with the coordination of state educational activities and services for public schools and for certain adult education and post-secondary programs. TEA plays a central role in decisions related to curriculum, teacher training and staff development, school certification, and teacher certification. Through its Commission on Standards for the Teaching Profession (CSTP), TEA ensures that school programs meet the current set of standards. Teams from CSTP visit campuses every five years to assess compliance and make recommendations on the continuation of programs (William Sanford, memorandum, February 2, 1988). TEA has deputy commissioners who supervise the major elements within the agency; their responsibilities include administration, approval, evaluation, and technical assistance for educational programs. The commissioner of education, the chief executive officer, recommends rules and regulations to the state Board of Education .

The Texas State Board of Education is the state-level policymaking entity. The board is in the process of developing a statewide system of computer services for educational and informational use (TEA,1986b, section 11.33 (b) (1), p. 41) and is charged with developing a long-range plan for "using technology-based systems for instructional purposes in the classroom; evaluating, developing, and acquiring computer software for use in the classroom; and fostering computer literacy among public school students" (TEA,1986b, section 14.021 (a), p. 79). Further, "the state will coordinate all public and private telecommunications systems for delivery of distance instruction and administrative services" (TEA, 1987, p. 62).

Related policy participants are local school districts, the federal Department of Education, regional education service centers, and the Texas Higher Education Coordinating Board. The education service centers offer a wide array of training and instructional services to teachers. TEA and the Coordinating Board share authority over the certification of institutions offering teacher training programs in the state.

In recent years, state-level decisionmakers in Texas have shown interest in the applications of educational technologies in meeting the state's educational needs. Discussions are underway regarding the future role of the state in promoting and coordinating technology usage. TEA, under the aegis of the state Board of Education and with the assistance of an advisory committee, has developed a long-range plan for technology. The plan dovetails with the state's overall long-range plan for education. In a separate but related effort, a software advisory committee has been created that reports to TEA's Division of Educational Technology.

Preservice Teachers

Standards for teacher certification in Texas have undergone considerable changes on at least three occasions in the past decade -- in 1979, 1984, and again in 1987 (Frances Sage, interview, February 25, 1988). Effective in the spring of 1984, as a result of passage of House Bill 72, a passing score on the pre-professional skills test (P-PST), along with a 2.5 minimum grade point average, became requirements for entry into teacher preparation programs (AACTE, 1986, p. 89). The reform bill also mandated the Examinations for the Certification of Educators in Texas (EXCET), which cover both general professional knowledge and content area specialties. EXCET was field tested in 1985 and has been required for certification since 1986 (AACTE, 1986, p. ix). The Texas "essential elements," which prescribe the content of courses taught in public primary and secondary schools, currently dictate the curriculum of teacher preparation colleges. Courses in the teacher preparation subject matter specialization sequence must include the appropriate elements as well as the objectives covering the subareas of the EXCET tests.

Basic knowledge of information processing technology has been required for initial certification since 1986 -- as a general education requirement and as a professional development requirement for education majors. The mandates for the courses are contained in title 19, chapter 75 of the Texas Administrative Code (chapter 137, subchapter M, parts (1) (g) and (4) (f)). Related offerings also have served as a program for in-service teachers (Gary Haseloff, interview, November 25, 1987).

Various teacher preparation programs, both public and private, address the general applications of technology to teaching and also the specific preparation of instructors of technology (TEA, 1987, p. 6). A representative course offered by The University of Texas at Austin's College of Education (EDC 371) covers the following topics: fundamentals of computer systems, programming in Basic, Pascal, or LOGO, computer-related terminology and use, history and development of computers, use of the computer as a tool, communicating instructions to the computer, problems and issues of computer use in society, and development of computer programs on selected mathematical topics (College of Education, The University of Texas at Austin, 1988). Various computer-science courses are allowed as substitutes.

At Southwest Texas State University (SWTSU), all prospective secondary teachers currently are required to take an educational technology course that covers both high- and low-technology applications ranging from computers to ditto machines. A regional needs appraisal conducted for SWTSU by the LBJ Institute for the Improvement of Teaching found that paperwork was a common complaint among teachers. In response to the appraisal, the SWTSU course emphasizes the practical uses of technology as administrative tools rather than as instructional devices, although students are encouraged to explore and evaluate software written for their subject areas (Kathryn Coulter, telephone interview, February 10, 1988).

A special situation exists for teachers of computer systems and information processing. The Information Processing Technology (IPT) endorsement developed by the Texas Education Agency documents the desired credentials for instructors of these technologies. Teacher training institutions will be allowed moderate flexibility in devising programs to meet the new standards (TEA, 1987, p. 1).

In-service Teachers

Several changes in the assessment and continued training and advancement of in-service teachers also have been instituted in recent years. The Texas Examination of Current Administrators and Teachers (TECAT), primarily a basic skills test, was administered to all current teachers and administrators in March 1986, and two further opportunities to pass the test were provided in the following summer. Nearly 99 percent of those tested passed.

A requirement beginning in the fall of 1986 that every junior high school student in the Texas schools take at least one semester in computer literacy created a temporary crisis because credentials had not been established to verify competence to teach the course. The crash training program devised to meet the crisis resulted in the certification of over 8,000 teachers (from a wide variety of subject areas) to teach computer literacy. The program was discontinued in 1986 when the immediate need was determined to have been met. As reported above, advanced standards for teachers of information processing and computer information systems have been developed by TEA.

The career ladder for Texas teachers devised in 1984 established a four-tier advancement plan. New and current teachers begin at level one with advancement contingent upon the number of years at each level, additional training or higher education course work, and performance. Each step carries additional salary. Master teachers, at the top of the hierarchy, are required to be in the classroom at least 60 percent of the day; the remainder of their time is spent in supervisory responsibilities (AACTE, 1986, p. 89).

In addition to the continuing education requirements for career advancement, teachers receive eight days per year of in-service training, four of which are reserved for administrative duties. Of the remainder, a small amount of training is available in educational technology (Elgin Schilhab, telephone interview, September 24, 1987). In-service training in technology may be provided by local education agencies, institutions of higher education, and 20 regional service centers throughout the state, as well as through private sources. Standards developed in 1984 require that all state colleges of education must maintain ongoing faculty development programs as a condition of state approval (AACTE, 1986, p. 90).

The State Plan for Regional Education Service Centers directs the centers to provide computer literacy training; the training is optional for teachers, as are all programs of the centers (Texas State Board of Education, 1986, p. 45). Course offerings consist mostly of short courses aimed at providing the state's required number of hours of teacher in-service training, as well as for hours required for teachers to progress along the state's career ladder (Judy Castlebury, interview, February 26, 1988).

The Texas Teacher Appraisal System (TTAS), developed by the 69th Legislature in compliance with House Bill 72, was implemented in the 1986-1987 school year. The system is hierarchically organized into domains, criteria, and performance indicators. None of these currently address specifically the use of instructional technologies, although the use of appropriate media is generally implied (Texas Education Code, 1987).

Educational Technology in Texas Schools

Although the state plays a major role in the areas of teacher preparation and the certification of teacher training programs, the actual use of classroom technology currently depends on the policies and finances of individual school districts and on the initiative of individual teachers. Many of the larger districts have staff members dedicated to coordinating training programs for their teachers and have developed plans for the implementation of technology in their schools. In the Austin Independent School District, the purchase of hardware has been centralized, while the selection of software is the responsibility of the individual teacher (Elgin Schilhab, telephone interview, September 24, 1987). Although the Austin secondary schools have accumulated numerous computers in recent years, particularly at the magnet schools for computer instruction, the computer labs are normally in use at least five periods per day for instruction in programming, and thus are not available for teachers in other disciplines. Simple counts of the equipment on hand say nothing of how the resources are to be utilized. The Houston Independent School District has created a Bureau of Technology which offers year-around training to administrators and teachers. The method used to disseminate knowledge of technology requires that one teacher from each campus be trained extensively in the use of technology. The individual then is available as a resource for others at the school.

The innovative use of computers for instruction by individual teachers may be hampered somewhat by the Texas "essential elements." Teachers may be reluctant to use educational software that is not written to parallel these elements exactly. In response, some publishers have developed "crosswalks" to correlate their software lessons with the essential elements. A statewide pilot project, the Texas Learning Technologies Group (TLTG), utilizes software specifically designed to meet the essential elements. The project aims to improve student interest and achievement in science and mathematics. TLTG was formed in 1985 by the Texas Association of School Boards; the project currently involves 26 pilot teachers in 17 classrooms (generally equipped with six computer-based interactive videodisk machines per classroom), serving 3,000 students across the state (TLTG, January 1989, p. 1). Universities involved in the project's teacher training program include North Texas State University, Texas A&M University, and The University of Texas at Austin. Data collected during the pilot phase (between September 1986 and August 1988) indicated that, on average, students participating in the TLTG reached higher levels of achievement than comparable students not participating. Differences were greatest for "low ability" students (TLTG, January 1989, p. 16).

Recent Legislative Changes Affecting Teachers in Texas

Just as the 1984 educational reforms and standards were becoming status quo, the standards again were revised in the 70th session of the Texas Legislature. The legislation grew out of recommendations of the Select Committee on Higher Education and was supported by the appointed state Board of Education. A debate has long existed in American education over whether teachers should be primarily subject-matter specialists or pedagogical experts. The recent legislation represents a major turn in the direction of subject-matter expertise. Senate Bill 994 eliminates the undergraduate degree in education, limits the number of education courses to 18 semester credit hours, and provides for an induction year (a supervised initial year of teaching).

The participants in the education policy process have not yet worked through all of the many details necessary to implement the recent education bills; thus it is impossible to state precisely what the impact of the bills may be. The legislature reversed itself with regard to teacher qualifications in a very short period of time. In 1984 it required of a *minimum* of 26 course hours in education, and in 1987 it changed the requirement to a *maximum* of 18 hours of education courses. Changes of this magnitude have repercussions throughout the educational system -- particularly in terms of teacher certification and the certification of teacher training institutions and their programs. Whether ability to use new classroom technology will improve or suffer as a result of the legislative changes in Texas remains to be seen.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter has addressed the question of how the use of technology in the classroom will affect teachers. Wide agreement has been reported that the role of the teacher will change, but less agreement was found on the specific nature and extent of the change. It has proven impossible to forecast the effects of technology on teachers without considering the determinants of the effects. Yet the determinants are in a state of flux due to uncertainties regarding broad trends affecting the teaching profession and uncertainties regarding technological developments (including issues of societal acceptance).

The various waves of educational reform have worked both for and against teacher autonomy. Several recent proposals have recommended decentralizing the administrative structure of schools in order to restore the freedom of teachers to make important decisions regarding curriculum and teaching methods. On the other hand, many recent reforms have emphasized accountability at the expense of autonomy, mandating to teachers the precise content of courses and the methods to be used in instruction. The accountability reforms usually are enforced through elaborate appraisal instruments that minutely specify desired teacher behaviors. Yet the degree of autonomy possessed by teachers will be a major influence on the successful adoption and implementation of technology in the schools. Recent progress in educational technology poses enormous implications for the delivery of schooling. A broad array of scenarios are possible, depending on the pace of technological advancement and the extent of adoption.

A great deal will depend on how the technologies are to be implemented. The use of technologies can be mandated by administrators, initiated by the teachers themselves, or achieved through some combination of the two. It is probably too early in the adoption process to centralize decisionmaking regarding technology. Instead, creativity and innovation are called for; these are best generated through teacher-to-teacher contact. Efforts to impose technology over the objections of teachers will fail. Nevertheless, simply waiting for all teachers to embrace technology on their own is not a viable option. The educational system is in need of bold modification, and failure to consider technology-intensive alternatives to traditional education could impose large social costs in terms of lost opportunities for significant improvement. But the vertical-horizontal dichotomy may be a false one. An array of alternatives is possible between the extremes -- for example, hardware or software could be centrally purchased and made available as optional resources for the teachers' use. Teachers then could be provided with monetary or other incentives to use the technologies.

Future teachers will need to possess all the skills currently required by their positions in addition to the new skills made necessary by technology. Possible skill acquisitions include learning to incorporate technologies into the curriculum, to operate the technologies as tools for instruction and administration, to diagnose student learning problems, to individualize instruction, to manage the new classroom, and to teach higher-order skills such as problem solving. Future teaching staffs could be divided according to new specialties, such as lecturers, teacher-programmers, long-distance teachers of specific subject matter, or system monitors whose role would be to free the master teacher for administration and long-range planning. Other outcomes might include the greater use of team teaching and interdisciplinary courses.

The teacher will be pivotal in determining the success or failure of technology-enhanced education. In turn, the effective use of classroom technological tools will depend on the quality of the training that the teacher receives at both the preservice and in-service levels. Many states have recently established requirements for technology training of preservice teachers; however, little data exist to show whether the training is effective or is correlated with greater eventual technology usage in the classroom. In-service training in technology is available from numerous sources, including colleges of education, school districts, professional organizations, and the private sector, but coordination mechanisms linking teachers with trainers often are absent. Training is delivered through a variety of formats and approaches, such as workshops and summer institutes. Major concerns exist regarding the need for measures of training effectiveness and follow-up training. One proposal would have two teachers from each school receive intensive training on an ongoing basis; the teachers then would act as resources for the rest of the faculty.

Basically, the components are in place for Texas to move forward in promoting technology for educational use. Despite the potential benefits of the technologies and their relatively recent (if incomplete) diffusion through the Texas schools, it is not clear that agreement has been reached by the many participants in the educational policy process regarding the best uses of the technologies. A significant barrier is institutional in nature -- the absence of a systematic model for school systems to follow to determine their educational needs, to evaluate the effectiveness of the technologies in meeting those needs, to incorporate the technologies into the curricula, and to train teachers to use the technologies effectively. A particular problem is the absence of incentives for individual teachers to assume the additional burden of incorporating technology into the curricula. Pockets of innovation exist in certain Texas schools; one of the state's many responsibilities is to identify the key ingredients of those programs and find ways to replicate these successes elsewhere.

The following recommendations are divided into two sections. The first section contains what can be viewed as general principles to follow in training teachers to use technology. The second section is specific to Texas; the recommendations therein are addressed to the appropriate entities.

General Recommendations

It is too early in the technology adoption-diffusion process to require teachers to use the new technologies; instead, efforts should be made to generate enthusiasm for their use by appealing to the collegiality and professionalism of teachers. One means of reducing resistance is to demonstrate to teachers the value of the technologies in terms of time and labor savings, for example, in performing mundane administrative tasks such as attendance and grading. As teachers become accustomed to using technology for administrative purposes, they may become interested in the new uses of technology in instruction. However, teachers should not be misled into believing that high-technology instruction will make classroom teaching easier.

As much as possible, technology training for teachers, whether preservice or in-service, should follow the attributes for successful training identified by the American Association for Colleges of Teacher Education in conjunction with the Educational Testing Service. The attributes were listed previously in this chapter.

Additional research is needed. The teacher is critical to the success or failure of technology in the classroom; the costs of training teachers may be higher than the combined costs of hardware and courseware. Therefore, changes in the skills required for effective use of the new technologies in teaching must be identified and incorporated into the preservice and in-service teacher training processes without delay. The training will be wasted if the technologies are not available to teachers and if teachers are not granted the autonomy to make decisions based on their training. Central clearinghouses must be established to collect and disseminate information relevant to new technologies and teaching.

Although the decision to make more extensive use of the new technologies in education must be guided by their impact on student achievement, rather than on the teaching profession, the teacher is the key to a successful transition. Any effective change requires the acceptance and support of the persons who must carry out decisions. These are best accomplished through the active participation of these people in decisionmaking. The input of teachers must be assured in determining the future uses of educational technologies, assessing the changes in their skill requirements, and making corresponding changes in the preparation, certification, and training of teachers. Educational technologies are rapidly changing; the approach developed to incorporate technology into the instructional process must be capable of ongoing comparisons of educational needs with technological capabilities.

To fully exploit the benefits of the new technologies at least initially will require that teachers be accorded great discretion and flexibility. Given the wide array of state and local regulations governing educational methods and content, teachers currently lack the autonomy necessary to initiate significant classroom innovation. Fortunately, the use of technological tools -- especially the computer -- may provide a partial solution to the problem by making it possible to centralize some decisions while decentralizing others. If properly implemented, technology can serve to enhance the autonomy and prestige of classroom teachers without sacrificing the accountability that society rightfully demands.

Specific Recommendations

Legislature

1. Texas should adopt the recommendations of the Carnegie Forum Task Force Report on Teaching as a Profession as a means of raising teaching standards and facilitating the recruitment and retention of capable teachers. Recent educational reforms in Texas, notably, the essential elements, the Texas Teachers Appraisal System and career ladder, the P-PST test, the TECAT test, EXCET tests, and Senate Bill 994, all emphasize teacher accountability at the possible expense of teacher autonomy and professionalism. The Carnegie report proposed a comprehensive approach to resolving the highly interrelated problems of recruitment, accountability, and autonomy and fully merits the state's support.

2. The legislature should be prepared to revise parts of the Texas Education Code needed to promote the effective and extensive use of technology in the Texas schools. A comprehensive plan for technology usage may require that many steps be taken in concert.

Texas State Board of Education

3. As the primary state policymaking entity in the area of education, the Texas State Board of Education must foster the participation of all relevant parties in making decisions regarding technology and teacher training. As consensus emerges regarding technology in Texas education, state Board of Education should articulate the relationship of technology with the state's broad long-range goals.

4. The state Board of Education should monitor the effects of the essential elements, the Texas Teachers Appraisal System and career ladder, computer literacy requirements, equipment distribution within schools, and Senate Bill 994 on the adoption of innovative practices involving technology, and make or recommend revisions as necessary:

5. The state Board of Education should consider funding district-level positions dedicated to educational technology in order to facilitate the necessary information exchange that must flow among teachers, schools, districts, and the state. The desired information pipeline could fail at any one of these points. At present, the larger and more prosperous school districts are more apt to have specialists in educational technology than are smaller, poorer districts.

Texas Education Agency (TEA)

6. TEA is the logical repository for needed information on technology usage and teacher training sources. Examples of successful applications of technology and training should be collected and published. A technology committee composed of representatives of teachers groups, the state Board of Education, the Texas Higher Education Coordinating board, regional education service centers, colleges of teacher education, districts, and the private sector could be established by TEA to ensure communication and coordination of efforts.

7. Through the Software Advisory Committee, the agency should continue its involvement in courseware evaluation and make that information available to districts, schools, and individual teachers. A newsletter format may prove useful in forwarding the information and in generating enthusiasm for technology training at the local level.

8. TEA should investigate establishing a loan program, in conjunction with the education service centers, that allows teachers to take computers and courseware home for examination and practice.

9. TEA should explore and quantify the possible economies of scale that could result from centralized state purchase and distribution of educational hardware and courseware. Related issues to be explored may include the extraction of liberal copying privileges on software and agreements with software developers that make the provision of initial teacher training a condition of purchase. Matters of distribution also must be considered if the state is to assume an active role in purchasing. The materials then could be made available through the educational service centers or provided directly to districts or school libraries, for example.

10. TEA should work with individual districts, preferably the poorer ones, to examine the feasibility of creating entire campuses designed around high-technology instruction. The creation of "Star Schools" would allow decisionmakers to observe first-hand the organizational implications of technology for schools and teachers. State "input" regulations governing the delivery of instruction might be suspended in these schools in favor of stringent "output" requirements based on gains in student achievement.

Texas Higher Education Coordinating Board

11. The Coordinating Board should evaluate and compare the technology training programs available through state institutions of higher education. If some campuses are found less proficient in their programs, the Coordinating Board could initiate a faculty sharing and training effort. The Coordinating Board also should participate in preparing recommendations for the legislature if statutes or rules require revision for the advancement of technology usage. Finally, the Coordinating Board, in conjunction with TEA, might examine the creation of a new credential in educational technology that could be incorporated into the state's career ladder for teachers.

Colleges of Teacher Education

12. Colleges of teacher education must undertake the task of researching the effects of technology on teacher skill requirements immediately. Research is needed on the following topics: integrating the technologies with learning theory, incorporating the technologies into the curriculum, identifying the emergent skill requirements of teachers, and measuring training effectiveness. Education colleges must maintain close ties with teachers in the field in order to upgrade, and ensure the relevance of, their offerings in technology.

13. Colleges of teacher education also must play a more vital role in providing technology training for in-service teachers.

Regional Education Service Centers

14. Education Service Centers should expand their roles as sources of training for teachers and as a group should compare their offerings in technology and attempt to make them of uniformly sound quality. Additionally, education service centers should become involved in developing measures of training effectiveness for use throughout the system. They also could play a significant role in the collection and distribution of hardware or courseware. Education service centers should consider hiring special traveling trainers that deliver on-site training among the campuses in their regions.

School Districts

15. In coordination with other actors, districts must make the resources more readily available to teachers, facilitate the training of teachers to use the technologies effectively, and reward teachers for innovative uses of the technologies. The issue of providing teacher incentives is probably best addressed at the district level, unless the state should decide to create a new level of certification or advancement based on expertise in educational technology. Possible incentives under district control are reduced course loads during initial implementation of a technology, salary credits, or paid time off for teachers pursuing training.

Schools

16. Schools must study the deployment of existing technology equipment. A common practice involves placing all of a school's computers in a computer lab that is used for teaching computer literacy, in fulfillment of the state's mandate in that area, or for teaching programming. The computers then are not available for teachers of other subjects. As a minimum, efforts should be made to ensure that at least one computer is available to each teacher for administrative use and for exploring software relevant to the teacher's specialty.

Chapter 6. The Organization and Financing of Educational Technology in Other States

The chapter describes the funding sources and governance structures utilized to implement educational technology programs in selected states. Information was obtained through structured telephone interviews with key policymakers. The aim of the survey was to provide information on options that may be appropriate for adaptation by Texas. Particular attention was paid to the effect of funding on the development of governance. Also covered was the treatment of costs in technology programs, recognizing that a major concern of most policymakers is the often high initial cost of adopting technological tools for instruction on a widespread basis.

With the advice of staff from the TEA Division of Research and Information, six states were selected to be surveyed: California, Florida, New York, North Carolina, South Carolina, and Utah. In all of these states, there is considerable activity in the area of educational technology. The telephone survey was designed to provide additional, up-to-date information regarding governance and funding issues in these "lead" states. A list of the questions used for the survey can be found in the conclusions to this chapter.

CALIFORNIA

According to Barbara Abbott, a Consultant in Education Technology for the Office of Educational Technology, California State Department of Education, the main program thrust has been on integrating the new technology into the education process with the objective of making teachers comfortable with technology rather than to affect student achievement. In addition, the current state plan for technology is based on "wants" assessment rather than "needs" assessment (telephone interview, April 14, 1988).

The California legislature demonstrated its commitment to educational technology with a budget of $9 million in the initial year of the technology plan which was increased to $15 million the second year and $26 million the third year. The fourth year of the technology plan, the budget was cut to $13 million in the wake of the widespread "tax revolts" that swept California that year (Barbara Abbott, telephone interview, April 14, 1988). State funding for new educational technologies has been considered as "seed money" for projects with supplemental funds coming from local taxes.

Education Technology Programs

As a result of program development in response to locally defined "wants" or "needs," projects in California have come in a variety of shapes and sizes. While provisions for equity are required by the state Department of Education, local districts have focused on efficacy or excellence. Program emphasis has been placed on curriculum reform with technology being used as an enhancement or supplement. In addition, technology programs have been pursued to alleviate teacher shortages, which have been experienced in specific curriculum areas and in certain geographic regions.

In order to facilitate the development and transfer of program design for both technology and curriculum, the state Department of Education has encouraged the utilization of the "model schools" structure.

The state Department of Education has conducted some software reviews and promoted "alignment" of software with the curriculum in order to stimulate consistent adoption across districts. However, due to budget problems, the state has not been able to provide any process for ongoing review of software (Barbara Abbot, telephone interview, April 14, 1988).

FLORIDA

According to Dave Britton, administrator for the Office of Educational Technology in the state Department of Education (telephone interview, March 24, 1988), public education in Florida reflected a generally good economic climate; funding of educational technology programs has not been a problem through legislative appropriations made from general state revenues. Private funds can be tapped through the participation of the state Department of Education with universities and colleges in joint effort projects. In addition, the state agency is allowed to accept donations of hardware from private sources but to date has accepted no money. Additional funding sources are outlined in the Florida Plan for Educational Technology and are characterized as implementation strategies for 1987-89. These implementation strategies are to target funding resources made available through programs such as the Primary Education Program, State and Federal Compensatory Education Programs, Job Training and Partnership Act Grants, Vocational Education Programs and Summer Institutes. Also, lottery funds generated in Florida have been targeted to instructional technology in order to meet specific needs of children at risk (Florida Department of Education, 1987).

An important feature of Florida's education structure is that the commissioner of education is the state's top education officer all education programs. With the top administrative position for elementary and secondary education, community colleges, and the university system residing in one office, a structural linkage facilitates communication and cooperation.

Education Technology Programs

The Florida Department of Education has identified several areas of emphasis for the use of educational technology in the state. These include the need to promote a climate of excellence in education, assure a supply of high quality teachers, provide diverse programs to meet the needs of at-risk students, strengthen educational partnerships, prepare students for a competitive world marketplace, and accommodate growth (Florida Department of Education, 1987).

The primary project in progress in Florida at this time is the statewide Data Communications Network . The commitment of the state to this project is indicated by the level of funding appropriated, which totaled $30 million between fiscal years 1982-83 and 1987-88, with an additional $8 million expected for 1988-89. The bulk of the appropriated funds have been used to purchase hardware, software, and application software for interfacing with sites and to establish a data base to facilitate reporting by the districts.

The Data Communications Network was initiated by the Legislature in 1981 as a joint project linking the university system, community colleges, and local districts. The Data Communications Network was justified on the basis of moving education into a new era. No attempt was made to justify the project on an economic basis, cost/time savings basis, or otherwise. The Network primarily was seen as a way to keep up with student mobility by facilitating the movement of student records throughout the state. In proposing the project to legislators, the Florida Department of Education pointed out a side benefit: the increased ability to gather and interpret data on program makeup (ethnic mix, age, sex, etc.) in response to requests for funding from districts. According to Britton, the biggest chore in developing the Data Communications Network plan was getting the three parties in the project to agree on common data elements in the student record. In order to resolve this problem, the state established articulation groups representing each party that met and developed a consensus on format, definitions, and standards.

The state Department of Education has been involved in joint effort projects with post secondary institutions in funding centers to evaluating software. Software evaluation in these centers primarily emphasizes a comparison and correlation with existing state education needs and capabilities.

Another project underway in Florida, the Instructional Strategies Enhancement program, was established to develop bulk discounts and purchasing incentives for technology purchases in the state. The state legislature appropriated $670,000 in initial funding for the purpose of implementing the program.

While no formal evaluation process has been established for the Data Communications Network program; all other program evaluations are conducted at the district level. Further, the state Department of Education has not attempted to allocate costs of programs on the basis of multiple usage, however, some allocation is done at the district level (Dave Britton, telephone interview, March 24, 1988).

NEW YORK

According to Peter F. Stoll, assistant director for the New York State Education Department, Center for Learning Technology Policy, Research, and Development, educational technology efforts in New York have been driven by three priorities: (1) excellence, equity, and efficiency as determined by productivity; (2) accountability; and (3) the contribution to economic revitalization (telephone interview, April 14, 1988). Business interest in education are reflected in these priorities. CEOs in the state have promoted the achievement of all three objectives simultaneously. According to Stoll, business leaders in the state want workers of the future to be more process-oriented, to possess more thinking skills, and to be more adaptable to change.

Project initiative primarily comes from the school district level, driven through a program of categorical aid for hardware and software, with funding from the state based on enrollment and wealth. This funding mechanism has been critical to equity and covers a broad range of technology.

The integration of technology into the curriculum is required and emphasized by the state Education Department in all new program developments. In addition, the state requires that a correlation be established between current curricular objectives and hardware applications in any proposed technology program. In requesting funding for technology programs, districts are required to make application for specific instruction and content areas.

Education leaders at both the state and district level recognize that successful implementation of new educational technologies depends primarily on staff development and training. New York spent $16 million to support ninety-nine Teacher Resource and Computer

Training Centers that served over 180,000 teachers and other education professionals statewide during the 1988-89 school year (New York State Department of Education, 1988, p. 1). Funding for these centers is based on competitive bids. Linkage is provided between education and business through requiring representation from both higher education and industry on the board of directors of each Teacher Center. Support of teachers' unions is required as a condition of every proposal for a Teacher Resource and Computer Training Center. Even with the support of teachers' unions, one problem that has continued has been the resistance of older teachers -- those who are expected to retire within five years -- to efforts requiring technology training.

In addition to teacher in-service training, New York recognizes the need to influence teacher quality through involvement in preservice training at institutions of higher education. Linkage has been established between public education and higher education in New York through research and development. The bulk of educational research for the public education sector is pursued in institutions of higher education with key institutions identified by the state Education Department. According to Stoll, since these institutions already conduct research, they are better equipped for the task. They have access to a variety of funding sources to supplement the work, including grants and endowments from federal, state, local, and private sources. Also, a better, quicker, more complete transfer of technology occurs because of the proximity of education students (telephone interview, April 14, 1988). The first such relationships developed were established with the New York Institute of Technology and Howard University in Washington D.C.

Individual programs in New York are evaluated according to requirements specified by the funding source. As stated by Stoll, "If you don't contribute to the funding, you have no say in the evaluation process (telephone interview, April 14, 1988)." While evaluation standards for state-funded programs are set by the state Education Department, the actual evaluation is conducted by the Legislative Program Evaluation Office. This structure separates the parties responsible for program operation from the evaluators in order to ensure objectivity. Evaluation priorities are established according to program priorities mentioned earlier: excellence, equity, and efficiency as determined by productivity, accountability, and the contribution to economic revitalization.

Education Technology Diffusion Programs

Education technology programs in the state of New York are initiated at the district level. Indeed, the state Education Department facilitates this initiative by encouraging the utilization of other existing institutions and sources such as the Office of Technology Assessment (OTA) and National Diffusion Network (NDN), whose main purpose is to transfer technological innovations to other sites. Through the NDN alone, 40 to 50 programs have been identified for replication. The state Education Department has further facilitated this process by identifying key high tech centers to coordinate education applications.

In addition to the previously mentioned efforts by the state to pursue teacher training, a mechanism for fostering teacher training in New York is the Teacher Summer Business Training Program,which reimburses teachers up to $1,000 for participation in training with applications that can be transferred back to the classroom. A major area of technology application is in agricultural education, which is primarily accomplished through the use of distance learning technologies (Peter F. Stoll, telephone interview, April 14, 1988).

NORTH CAROLINA

North Carolina's 140 local school districts are divided into six sub-regions, each headed by a state assistant superintendent. These positions are comparable in authority to the deputy commissioner level in the state of Texas. At this time North Carolina is not experiencing any notable economic problems, and funding for educational programs generally does not meet any significant resistance from legislative sources. In addition, many school districts have funding sources other than state-appropriated funds, bond issues, or district tax revenues; namely, private funding sources available through the use of a grant mechanism, which has been patterned after federal grants.

Education Technology Programs

While smaller scale programs are under various stages of development, North Carolina's technology efforts focus on three major programs: (1) purchase of computers and software to achieve a computer/student ratio of 1:23; (2) establishment of a telecommunications and Electric Pages network linking the six subregions across the state; and (3) establishment and expansion of distance learning technologies, including a satellite network, TI-IN, to provjde curriculum to all districts in the state.

Computer Technology Programs. The integration of computer technology into North Carolina schools has been made possible by a state appropriation of $28.5 million. The goal of the state in the appropriation of these funds is to achieve a computer/student ration of 1:23. The funds are distributed to districts on the basis of specific plans submitted by the district to the state Department of Education for approval. This dedicated appropriation is used by the districts to offset costs of hardware and software only. Funding for other costs associated with technology programs, such as training, maintenance, facilities construction or modification, and replacement, must be provided from other sources. No attempt has been made to allocate the costs associated with the technology plans to secondary uses of hardware and software.

A basic element required in plans submitted by the districts is the provision of ongoing evaluation to measure the effectiveness of the project. The definitions and standards for outcomes from programs are established at the state level, determined in part through pilot demonstration projects established by the state. Using these statewide standards, evaluations are proposed in the technology plans and implemented at the school district level.

Telecommunications. The impetus for the development of a statewide education telecommunications network came from the six state assistant superintendents, whose main goal was to establish better communications between them and their respective areas. Communication was achieved across existing phone lines through an electronic bulletin board system and electronic mail.

State purchases were for hardware such as modems and software necessary to provide linkage between these areas. Initially the system was to be used by the superintendents and their staffs, however, North Carolina planned to begin bringing the schools on-line by July 1988. Funds for the project came from the operating budgets of each superintendent.

Distance Learning. North Carolina has adopted the TI-IN network to provide instruction via a satellite downlink to remote receiving sites throughout the state. The impetus for pursuing this technology has been the need to ensure educational equity as measured by the offering of an established set of basic educational requirements in every school district. Basic educational requirements are set at the state level; evaluation of the program's effectiveness in delivering basic educational requirements is made at the state level (Elsie Brumback, telephone interview, March 24, 1988).

SOUTH CAROLINA

The educational setting in South Carolina is dominated by the mandate for education reform provided by the state's Education Improvement Act of 1984 (EIA). The activity initiated by the EIA and unfavorable economic conditions in South Carolina have made funding somewhat more of an issue that in past years. As a result, a variety of funding sources is utilized. For example, the South Carolina Educational Television network (SCETV) has been chartered such that they can accept private funds in the form of grants, donations, and endowments (Bob Reese, telephone interview, March 31, 1988). Programs implemented by EIA are funded by a one-cent increase in the state sales tax (Hill, 1987, p. 87).

State and federal sources provide the bulk of the funds for technology programs at all levels. Yet locally generated funds provide a significant portion, as attested to by Clyde Green, the director of the Instructional Technology Office, South Carolina Department of Education. According to Green, the only state money available to schools is drawn from remediation, vocational education and incentive programs in the 1984 Educational Improvement Act. School districts spent $14.7 million on computer hardware and software in 1986. More than half the money came from federal money or the EIA. Local districts accounted for 20 percent of hardware and software expenditures; the remaining monies came from local businesses or parent-teacher organizations (Johnson, 1987, p. 10B).

Education Technology Programs

As a result of the EIA, statewide technology efforts in South Carolina have centered around two major areas; distance learning and the reduction of teacher's paperwork through the use of computer technology. This emphasis is the result of the need for centralized planning and coordination for programs which could have a wide distribution or effect, as in distance-learning technologies, and the need to provide uniformity of effort and direction, such as paperwork required for reporting to the state Department of Education. Local district efforts have centered around those programs that primarily utilize computer technology and are more limited in their geographical scope or application, such as computer-assisted instruction (CAI) or computer-based drill and practice.

Distance Learning Technologies. Technology programs in distance learning for the state of South Carolina have been pursued primarily as a result of the need to address equity concerns. In addition, distance learning technologies have been viewed as effective in addressing teacher shortages, which are experienced in specific curriculum areas and in certain geographic regions. Distance learning across the state has been achieved primarily through the Instructional Television Fixed Service (ITFS) and Interactive Television (ITV) services offered by the South Carolina Educational Television (SCETV) network.

SCETV, a state owned and operated system, provides the production, printing, and broadcasting services required by the ITFS and ITV services. Due to the greater hardware costs associated with ITV, SCETV provides funds for this service from its regular operating budget. The funds are allocated on a matching basis to support local district initiatives.

The SCETV network is evaluated by the state Department of Education, which primarily emphasizes air time offered (as a measure of access), courses offered (as a measure of variety), and an actual count of users, including students, teachers, and administrators. While evaluation is required and pursued, the attitude is not one of urgency on the part of the state agency. This sentiment is reflected by Bob Reese, chief supervisor for utilization, Office of Instructional Technology, in stating that "when television is providing curriculum that a student would not otherwise have, you don't need a lot of research to prove the value of it " (telephone interview, March 31, 1988).

Paperwork Reduction. One of the outcomes of the EIA was the mandate to reduce teachers' paperwork through the use of computer technology. As a result, the Pathways Project was initiated. The Pathways Project, an organized effort to take advantage of standardized software used in teacher paperwork reduction, grew out of the suggestions of a steering committee assembled by the Department of Education, which coordinated with local school districts in selecting the members. The steering committee identified several areas, mainly administrative, in which to concentrate reduction efforts. These included recordkeeping for the South Carolina Basic Skills Assessment Program (BSAP), test development and scoring, grade reporting, student scheduling, attendance reporting, and word processing (Hill, 1987, p. 88).

According to Jack Hill, systems manager for the Educational Data Center, which is charged with responsibility for the Pathways Project, once the Osiris software, developed by the Tamarac Software group, was selected through a competitive request-for-proposals process, the agency entered into a statewide licensing agreement in order to distribute copies to the local districts on a free-of-charge basis (telephone interview, April 14, 1988). Hardware costs incurred by the schools in implementing the Pathways Project are reimbursed by the state Department of Education when purchases are made on the State Term Contract for Microcomputers (Hill, 1987, p. 89). These procedures provide strong incentives for districts to buy compatible hardware, even though the state does not require its purchase.

Training for the Pathways Project is coordinated through the state's technical schools and developed by the state Department of Education. Currently, training is accomplished through the use of four training teams made up of two trainers and 13 computers each. In addition, project support is provided by a hotline service, which is available to a designated liaison in each of the 92 districts currently using the system.

As a part of the Pathways Project, the state Department of Education annually publishes an advisory listing of software correlated to the BSAP and participates in the Software Evaluation Exchange Dissemination (SEED) project involving several southern states (Johnson, 1987, p. 10B).

In the near future, the Pathways Project will be expanded to include additional modules, called the Classroom Management System (CMS). The emphasis of the CMS will be paperwork reduction in classroom applications. As an added incentive for districts to sign up for the program, districts will be required to submit reports in the state-approved format during the 1988-89 school year or records will not be accepted (Jack Hill, telephone interview, April 14, 1988).

Other Computer-Based Programs. Specific computer technology program initiatives are driven by the districts, with the state agency acting only in the capacity of a technical advisor or coordinator. A major aspect of district initiatives is recognition of the usefulness of the computer in drill and practice to reinforce basic skills in reading, writing, and mathematics. In addition, it is recognized that many applications of computer technology allow individualized instruction and immediate reinforcement of student effort, both of which are considered key elements in improving basic skills. That this structure of district-driven initiatives aids the integration of technology into the schools is indicated by the growth in computer usage in South Carolina elementary and secondary schools, which increased from 4,054 in 1983 to 24,041 in 1986 (Johnson, 1987, p. 10B).

UTAH

Education in Utah is heavily influenced by geographic and economic considerations. The state of Utah is characterized by a wide dispersion of population in isolated areas. Regions of the southern and eastern parts of the state, which are primarily Indian reservations, are geographically remote and economically disadvantaged. Economic conditions in the state generally have been plagued with slow growth and increasing public needs. Dale Steadman, technology specialist for the Office of Research and Development, Utah State Office for Public Education, compares the state's situation with that of Texas "in that the public education agency is faced with meeting needs that are expanding at a rate faster than are the resources required" (telephone interview, March 30, 1988).

Educational technology programs have proliferated over the last several years, and a master plan for technology has been implemented on the state and regional levels. For the most part, however, programs have developed from the district level to address local needs with little direction from the state Office for Public Education. As a result of geographic and economic needs, educational technology programs have primarily taken the shape of distance learning technologies. While past programs have been initiated primarily at the local district level in response to local needs, impetus for future program development may increasingly come from the state. This impetus will develop as districts respond to the newly defined core curriculum required by the state for graduation from high school.

While the issue of equity has been the overriding concern of state and local district educators, many programs have been pursued for economic reasons as well, specifically, to hold down the cost of hiring new teachers required for increasing student populations. Technologies have been used to leverage the talents of master teachers and to reduce the need for new hires.

Even though the primary initiative has come from the school district level, the state has provided guidance and technical assistance. The state has established communications standards for the districts to follow, especially for reporting requirements. The state maintains a Technology Center, which acts as an information repository and provides technical advice for the districts. In addition, the Technology Center provides and/or coordinates in-service training programs offered to teachers across the state. Software reviews are maintained on statewide data base; but this data base is neither comprehensive nor up to date due to the magnitude of the task and the lack of funding commitment from the legislature (Robert Ives, telephone interview, April 14, 1988).

The state has not attempted to tap private funding sources. Funding has come from the general operating budget . Funds are allotted by the state office to districts that request funding on the merits of the programs proposed. Funding from the state is provided for the curriculum components only. No funding comes from the state for district hardware purchases; however, the Utah State Office of Education does act as a technical advisor for district purchases of hardware (Robert Ives, telephone interview, April 14, 1988).

While not the general rule, funds have come to districts in line-item appropriations from the legislature, as in the case of the system serving the poorer districts in the southeast portion of the state. According to Robert Ives, director of the technology center, Utah State Office of Education, productivity grants are provided by the state legislature to districts that want to start new projects to enhance the efficiency of education delivery or administration. No attempt has been made to allocate the costs of programs according to additional uses by either local districts or the state Office of Education.

The Utah State Office of Education is responsible for reviewing and evaluating projects funded by the state (Robert Ives, telephone interview, April 14, 1988). Program evaluations, provided for in the initial funding request from the district, are made by third parties. Evaluations are made on the basis of program output measured according to the specific need being addressed. For example, the distance education system used in the poorer southeast region has been implemented to achieve educational equity; therefore, program output is measured in terms of newly available course offerings. This remains the criterion as long as the students participating in these distance-delivered courses are passing, or alternatively, doing at least as well as students in conventionally delivered courses.

Education Technology Programs

Utah's distance learning projects have been implemented largely as a result of geographic and economic imperatives. Since many of these programs have developed historically from district-level initiatives, a variety of projects is underway.

A distance-learning project provides instruction in Spanish and other foreign languages through the use of satellite up-links. The project is a partnership of local districts, the IBM Corporation, and Bonneville Communications Satellites, coordinated through the Utah State Office of Education.

Educational programming is provided through the Salt Lake City PBS affiliate, KUED, which provides the state agency with a block of program time (9 a.m. to 3 p.m. Monday through Friday) in order to provide enrichment material in support of core curriculum (science, math, languages, etc.). English and computer data courses are provided through live broadcast programs originating at two remote sites in the state for distribution from Salt Lake City by KUED to the rest of the state. Next year calculus and concurrent enrollment will be added to the curriculum offered. ITFS exists in the state and can be accessed by public education, but is mainly used by the higher education system.

The state owns and operates the "Microwave Backbone," an interactive video system developed with funding from the Department of Commerce through NTIA. The system is operated by the higher education and state transportation agencies, and public education accesses it mainly for educational administration and teacher in-service training through a lease arrangement . However, a microwave TV system is used to link five high schools within one district to provide instruction in math, language, and science. This system will be linked to the state's universities to provide higher-level courses in the future.

Courses are offered through the use of audio-graphics, which is transmitted across phone lines. This program sometimes utilizes slow scan video and fax machines for data transmission. This system is used because of lower cost as compared to transmission by satellite or microwave. Some areas of the state also utilize low-power television transmission for delivering instruction.

An Urban Teaching Center in the Jordan district, one of the state's largest, uses audio-graphics to link all five of its high schools (Dale Steadman, telephone interview, March 20, 1988).

Technology has been identified as one of the core curriculum elements students are required to master in order to graduate. Districts have the choice of offering technology curriculum as either a discrete course or as an integral part of other curricula (Robert Ives, telephone interview, April 14, 1988).

CONCLUSIONS

Conclusions drawn from the experiences in the six states are organized according to the questions used to guide the interviews. The questions were organized according to three major categories: programs, funding and costs, and evaluation.

Programs

What have been some major programs of educational technology in your state?

While specific programs varied greatly between and within states, programs could be grouped according to two broad categories: (1) programs whose scope and application were limited either by geographical, economic, institutional, or governance considerations, and (2) programs whose scope or application could be applied on a statewide basis or at least across institutional and governance boundaries.

All of the states contacted encouraged program initiatives originating at the district level. The degree of district autonomy varied from state to state but was consistent regarding the type of program which was delegated to the districts for development: programs whose scope and application is limited either by geographical, economic, institutional, or governance considerations. A good example is computer-assisted instruction (CAI); it normally falls entirely within the jurisdiction of one governance structure or district. Under usual circumstances, the involvement of one district in a CAI program has no effect or bearing on the ability of a neighboring district to achieve its educational goals, especially if district program initiatives are funded from local taxes and do not compete with other districts for state or federal funds.

State program initiatives were concerned with those programs whose scope or application could be applied on a statewide basis or at least across institutional and governance boundaries. An example is distance-learning programs whose benefits and effects are available to several districts. State responsibility for these programs has grown out of the need to coordinate program usage and access as well as the larger imperative to pursue statewide goals such as equity and economic development.

Funding and Costs

What funding mechanism or structure do you utilize to provide for the use of technology in education delivery? What are the various funding sources?

Funding mechanisms and sources utilized in the various states have been determined primarily on the basis of economic conditions within the state. In states experiencing no significant economic crisis (North Carolina, South Carolina, Florida), funds for technology programs usually originated either from legislatively appropriated funds dedicated to that purpose or out of the state Department of Education's regular operating budget.

In states where economic concerns were dominant (New York, California, Utah), greater emphasis was placed on using local tax efforts, federal funds provided through existing programs, and private resources. Private resources were tapped through partnerships with universities and colleges, utilizing their ability to accept grants, donations, and endowments.

Funding requests made to the state Department of Educations were granted primarily on the basis of plans submitted by the districts according to criteria set forth at the state level. Criteria included standards, curriculum, equity, economic conditions, evaluation, and accountability requirements. The use of funds granted by the state Department of Educations could be limited to specific aspects of a given program, such as hardware purchases or training components, or applied at the discretion of the implementing district or other entity.

Matching funds provided by the state Department of Education or legislature to support local initiatives are a funding mechanism used in some states (South Carolina). This mechanism has several benefits: it stimulates creativity on the part of local districts, it spreads the cost of technology programs, and it provides for input and influence from the state Department of Education. Other funding sources that states have utilized are proceeds from lotteries (Florida) and a dedicated one-cent increase in the state's sales tax (South Carolina).

Do you have the legal status to accept donations of assets or money from private sources? If so, how is this accomplished?

In addition to utilizing donations from private sources through partnerships with institutions of higher education, state agencies and local districts have tapped the private sector directly. Although the private sector remains a relatively minor source of funding, donations of hardware, software, and technical assistance have come directly to both the state agencies and local districts. Donations of money have been rare and limited to a few districts in South Carolina.

No special legal status or statutory requirements controlling the ability of public education institutions to accept donations of assets or money from private sources were identified by the states.

In the requests for funding, how do you justify the expenditure to the funding sources?

In states experiencing favorable economic circumstances, justification for expenditures on educational technologies was not a significant issue. In these "prosperous" states, the impetus for technology programs came from a perceived need to address broad goals of education such as equity and excellence (New York). A major exception was the desire to effect time savings in the area of paperwork reduction in South Carolina.

Motivation for pursuing technology comes from the need felt by some states to simply "bring education into a new era" (Florida) or to keep up with the innovations of other states (Utah). In addition, some technology programs have been justified partially on the basis of secondary benefits to policymakers, such as the improvements in available information expected with the Data Communications Network in Florida.

States experiencing tighter economic conditions tend to justify their educational technology programs on a more concrete basis, generally on the basis of savings in time or cost. One significant area of cost savings advocated is the effect of technology on the need to hire new teachers to meet the needs of expanding enrollment (Utah, New York, California). A variation on this argument is that technology leverages the talents of existing master teachers and thereby extends their influence beyond the normal classroom to students in remote locations who otherwise would not have such learning opportunities (Utah).

In all cases, the justification for expenditures on *technological tools* was distinguished from that for *program* expenditures. In the states examined, justification for expenditures on specific programs was made on an economic basis alone. In other words, when choosing between programs, the program judged to deliver the most educational benefit for the dollar was the one that received funding.

In allocating costs have you made any attempt to charge costs to areas that could/would benefit from the technologies used in a particular program (secondary uses of hardware)?

With one exception, no attempt was made by state Department of Education or districts to allocate costs associated with technology programs according to secondary uses. Only certain districts in Florida made some attempt to do so. Given the flexibility of most technologies and the possibility of dual or multiple uses (other than those associated specifically with the program under evaluation), it may be entirely appropriate to allocate portions of the capital expenditures to other areas on the campus or in the district. Such an allocation of costs according to multiple uses may provide a more accurate picture of the costs associated with a given benefit for education.

What are the costs you associate with a particular program of educational technology?

Costs associated with educational technology programs that were recognized by states in their survey responses included hardware, software, training, curriculum, research and development, maintenance, and construction costs. Revealing were categories of costs not mentioned in the responses such costs as security, replacement, and opportunity costs.

Mentioned as most important was training for teachers, administrators, and staff. Texas can learn a lot from approaches used in other states to train instructional staff in new technologies. The peer teacher training approach used in the New York State Teacher Resource and Computer Training Centers seems especially worthy of attention.

Evaluation

At what level do you evaluate the benefits of educational technology, on a program-by-program basis at the district level or systemwide at the state level?

Programs fell into two categories according to the scope or application of the particular project in question. Programs such as distance learning and communications networks were evaluated at the state level on a systemwide basis. Programs conducted at the local level, such as the application of CAI, were evaluated by the districts on a program-by-program basis.

The most significant factor determining where the responsibility and control over the evaluation process resides is funding. While generally implied in the evaluation structures in the several states, the relationship between funding and evaluation was most explicitly recognized in

New York by Dr. Stoll who concluded: "If you don't contribute to the funding, you have no say in the evaluation process" (telephone interview, April 14, 1988).

How do you define the output from a program of educational technology? What methods and by what "yard stick" do you measure technology programs?

All states defined the output from a program of educational technology according to the goals of the particular program. In New York, evaluation priorities were established in accord with three general statewide priorities. In most cases, technology programs were evaluated according to output of the program rather than the effect on student performance. For example, evaluations of distance learning have focused on the number of courses offered, program hours transmitted, and the number of end users. No explicit mention was made of the effect on student achievement in South Carolina's and Utah's distance learning programs; student achievement was expected only to be at least the same as in conventionally delivered courses.

At what level (state, district, campus, etc.) and by what mechanism are these standards and measures determined?

In all cases the authority to establish standards and measures derived from funding. Authority and control over programs was clearly in proportion to the funding input from any given level. Governance considerations such as implementation authority, accountability, and evaluation design all originate with and are delegated by the funding source. The best evidence of this relationship is the requirements typically attached to the provision of funds for a given program. The case of South Carolina's Pathways Project to reduce paperwork offers a good illustration. Beginning in 1988, the South Carolina Department of Education required any records submitted by districts to be in the approved computer-generated format. While this requirement for conformity to a state standard is not tied to granting or withdrawing funds from the district, it should be noted that the South Carolina Department of Education offers funding to districts to make it possible for them to comply with reporting requirements.

Chapter 7. Financing Technological Change: How Texas Can Pay for It

New educational technologies hold great promise for improving school and classroom management, promoting individualized student learning, increasing the speed of mastery, creating greater interest in subject matter, and preparing students for the use of information technologies in their work lives. Much has been written about the potential of new technology in schools. Previous chapters of this report have outlined many of the issues relating to the implementation of several kinds of technology. However, little has been written anywhere about how to pay for the machines of which futurists dream. What innovative financial arrangements can be made to underwrite the cost of installing, maintaining, and using high technology? What issues do these arrangements raise?

Matters of public school finance immediately raise questions about which level of government should pay for which components of educational costs. These questions are complex, involving assumptions about control over schools and fairness to both taxpayers and students. In Texas, federal, state, and local governments all contribute some revenue to education. Because the introduction of electronic technologies into schools is relatively recent, established patterns of funding have not yet evolved. In an environment of change, funding arrangements have been unique to each district.

This chapter suggests innovative ways in which the Texas school system can finance a major technology program and addresses some policy issues related to the acquisition and financing of technology. Both state and local methods of financing are explored, particularly those methods that are useful during a period of fiscal constraint. Although a wide variety of financing possibilities exist, discussion is limited to a selected number of feasible and important options. An assumption underlying the discussion is that the state will initiate the technology program and exert some control over the shape it takes. Throughout the chapter, emphasis is placed on the equity of possible funding arrangements.

TWIN POLICY GOALS: EQUITY AND EXCELLENCE

The design of a technology program and its method of finance depends on the goal the state wants to achieve. The Texas Education Agency's *Long Range Plan for Technology* lists several justifications for the increased use of technology in public schools. These include responding to social and economic challenges in the state and nation, fulfilling legislative mandates, achieving the mission of quality, equity, and accountability in public schools, and reaching a vision of the future (1988, p. 9-31). The plan enumerates a variety of ways in which technology can fulfill these goals, including aiding at-risk populations, increasing basic skills attainment, motivating students, developing higher-order thinking skills, changing the curriculum, delivering the curriculum, aiding students with special needs, easing teacher shortages, improving the management of education, and containing costs. These include a wide range of aims, the achievement of which will require several types of programs.

One objective may be to place a certain amount or proportion of equipment in every school. The State Board of Education may decide that one of the above objectives would be served best by introducing a certain form of technology into all the schools. If an even distribution of resources is the overriding concern of the education system, this may be the appropriate goal to pursue. It may also be appropriate if the state's goal is to create a statewide technology infrastructure to link schools together.

If, instead, the goal is to improve schools through the use of technology, wherever technology is an appropriate means, the Texas Education Agency (TEA) should attempt to identify and fund school-based or district-based *programs* that aim to improve the schools. The programs will vary from district to district because each district has different needs and circumstances. In this case, equity is better described in terms of comparable outcomes rather than inputs. The state education system will treat districts most equitably when all students are enabled to achieve at least minimum levels of performance, regardless of their district's wealth. The remainder of this chapter proceeds from the assumption that school improvement is the more desirable goal, although equity in terms of access to funding and other resources remains a central concern.

Different methods of funding technology have different strengths and incentives built into them, besides those concerning equity. Some methods would minimize the costs of implementation; others would encourage the adoption of technology in local districts; and others would assure the development of high-quality technology products or plans in the schools. The state's goals and constraints will determine the most appropriate methods of finance and will affect how technology is implemented and used.

Two investment options are available to the state. Texas may invest directly in the schools by supporting the capital and operating costs of a technology program and/or it may invest in the development of educational software. Although the latter avenue would assist Texas schools in obtaining high-quality software and curricular materials, it would not relieve school districts of their current and future burdens of purchasing and maintaining hardware and training personnel.

As the state plans its program for technology expansion in the school system, it must consider not only which approaches will benefit students most, but also whether those plans are affordable by either the state or the districts. At present, both state and local governments are strained to provide current services. Although the state's economy can be expected to improve in the future, property values are not expected to rise quickly to refill school district coffers. Many districts are still struggling to meet maximum classroom size requirements and other provisions mandated by House Bill 72 in 1984 (Lewis Wilks, telephone interview, June 27, 1988). Therefore, the state should not mandate costly programs that the districts must finance fully.

Another consideration is whether the state plans to provide technology funds to districts one time or on an ongoing basis. One-time funds can be used to make capital purchases or to finance short-term demonstration projects. Districts then have to consider whether they can assume the full cost of continuing a project before they ever begin it. Ongoing funds have the advantage of providing predictable revenue to districts for their programs. Obviously, this kind of funding adds to the permanent revenue needs of the state.

THE DISTRIBUTION OF MICROCOMPUTERS IN TEXAS SCHOOLS

This section describes what is known about how technology, particularly microcomputers, is distributed throughout school districts in Texas. Although technological tools for education include telecommunications equipment and video technology as well as computers, microcomputers are used more widely and data about them are more readily available.

Trends in computer distribution are relevant to a discussion of school finance because they help to identify the types of schools and districts that may have difficulty in acquiring technology.

If the state intends to encourage the spread of educational technology, it may need to provide special assistance to certain districts, especially extra funding and planning and support services. A description of distribution is not a fool-proof indicator of overall financial need; other measures, such as property wealth, serve that purpose better. Nevertheless, underlying this analysis is an assumption that districts with relatively little hardware would like to own more but are constrained from making further purchases.

Overall patterns of computer use in Texas and the United States show that schools everywhere are increasingly involved with new educational technologies. Quality Education Data, Inc. (QED), a market research firm, found that 95 percent of all Texas schools used microcomputers and 92 percent used video equipment in 1988 (QED, 1988, p. 168). QED ranked Texas, which was third among the states in total number of computers in schools (104,014), twenty-fourth among the states in terms of the ratio of students to computers, with a density ratio of 30.5 students per computer for the school year 1987-88. The five states with the lowest density ratios were Wyoming, 16.5 students per computer; Alaska, 18.1; Minnesota, 20.3; the District of Columbia, 22.0; and New York, 23.8. However, only New York has an enrollment level near that of Texas. The average ratio for all states is 31.9 (QED, 1988, pp. 184-86).

These numbers depict a transitional state for use of technology in schools. Schools are rapidly acquiring more microcomputers. Only two years ago, in 1985-86, schools in Texas had 60,234 microcomputers, about 58 percent of the current number. The ratio of students per computer at that time was 50.3. In 1983-84 the ratio was 145 students per computer (QED, 1986, p. 160). Thus, over 40,000 computers have been installed in Texas schools during the last two years. No doubt computer purchases have been spurred by the introduction of a required computer literacy course for seventh or eighth graders across Texas.

Trends concerning computer usage can be seen among school districts throughout the U.S. QED reported in 1988 that enrollment size is the best predictor of microcomputer usage in schools. Large schools are more likely to have microcomputers, although the gap between small and large schools has narrowed considerably since the early 1980s. While only 77 percent of the smallest elementary schools (with enrollment under 100) had computers in 1987-88, 92 percent of the largest schools (with enrollment of 1,000 or more) used computers. Figures for junior and senior high schools reflect the same trend (QED, 1988, pp. 8-9).

QED found that relative wealth, as measured by the percentage of children living within a district who qualify for federally funded compensatory education programs, recently has become a weaker indicator of computer usage. In 1987-88, 93 percent of schools with poor relative wealth had microcomputers compared to 95 percent of schools with average relative wealth, and 97 percent of schools with high relative wealth (QED, 1988, pp. 13-14). Poor schools have made larger gains in acquiring computers since the mid-1980s. Also, in the early 1980s, districts with high minority enrollments were less likely to have computers. Since 1984, however, the reverse has become true. Districts with no minorities now lag behind other districts, perhaps because districts with only white students tend to be smaller (QED, 1988, pp. 16-17). Although small and rural schools are less likely to have microcomputers, those that do use them tend to have fewer students per computer. This finding is probably related to their low enrollment levels (QED, 1988, pp. 22, 2–6).

Expenditure per pupil also is a predictor of microcomputer usage. As might be expected, schools with a medium or high expenditure per pupil have more computers than low-spending schools (QED, 1988, pp. 23-25). Similarly, schools with high relative wealth show lower density ratios, except at the senior-high level, where the difference is slight or nonexistent (QED, 1988, pp. 27-29).

Table 2

Operating Expense, Microcomputer Density Ratio, and Wealth in the Twenty-Three Largest School Districts in Texas

District Name	1986-87 Total Current Operating Expense Per Student	1987-88 Density Ratio	1986 Market Value of Property Per Student
Richardson ISD	$3,823	21.31	$411,198
Austin ISD	3,653	20.10	414,602
Alief ISD	3,396	38.63	271,400
Dallas ISD	3,362	26.61	413,794
Plano ISD	3,356	6.40	385,104
Cypress-Fairbanks ISD	3,327	21.42	268,020
San Antonio	3,281	25.72	130,189
****Statewide average**	**3,088**	**30.48**	**218,206**
Brownsville ISD	3,082	30.58	52,610
Ector County ISD	3,046	26.10	202,427
Lubbock ISD	3,031	23.10	142,285
Pasadena ISD	3,014	49.27	146,137
Corpus Christi ISD	2,980	27.22	148,618
Houston ISD	2,952	18.18	287,449
Fort Bend ISD	2,947	60.01	197,002
Amarillo ISD	2,944	27.52	152,146
North East ISD	2,925	49.71	297,609
Arlington ISD	2,879	25.73	307,871
Fort Worth ISD	2,857	32.29	231,778
Garland ISD	2,838	69.70	203,440
El Paso ISD	2,798	94.76	106,511
Ysleta ISD	2,764	33.65	75,556
Northside ISD	2,660	19.23	223,477
Aldine ISD	2,504	45.57	184,419

Sources: QED. 1988a. "Computer Usage in Large Districts, 1987-88 School Year." Denver: QED, Inc.; QED. 1988b. Microcomputer and VCR Usage in Schools: 1982-1988. Second Edition. Denver: QED, Inc.; and Texas Research League. n.d. *Bench Marks for 1987-88 School District Budgets in Texas*. Austin, pp. 6, 8.

QED surveyed large school districts in the United States, including 23 of Texas's largest districts, about computer usage. Table 2 shows the microcomputer density ratios of the 23 largest school districts in Texas, along with the budgeted operating expense per student for 1986-87 and the market value of property in each district. Market value is the measure of a district's property wealth or tax base. No obvious relationship between these data is apparent from looking at the table, but statistical analysis shows a mild negative correlation between current operating expense and the density ratio (r = -0.4194, 0.05 significance level). This means that higher operating expenses are somewhat related to a larger number of computers for the size of the student body. However, the correlation coefficient for market value and density ratio is not statistically significant (r = -0.3996, 0.05 significance level). These observations are not surprising, as it might be expected that the size of a district's operating budget would affect its ability to afford educational technology. Because the state supplements the local districts' property tax receipts, high market value would not necessarily be linked directly to heavy use of computers. In the absence of more comprehensive information, these data for 1987-88 provide some indication of the distribution of educational technology in Texas districts. The 23 districts had a total enrollment of 1,161,358 students in the fall of 1986 (Texas Research League, n.d., p. 6), comprising 36.4 percent of the state's total enrollment. At the time of the survey, they used 45,450 microcomputers (QED, 1988a), or 43.7 percent of the total number of computers in Texas schools. Comparing these two percentages, it appears that large districts in the state have more than their proportionate share of microcomputers.

However, the distribution problem is not so neatly diagnosed. Among the 23 largest districts, the computer density ratios vary tremendously. On the one hand, Plano ISD has one of the lowest ratios in the nation, with 6.4 students per computer. At the other extreme, El Paso ISD has one of the highest among large districts, with 94.8 students per computer (QED, 1988a). The average ratio among the 23 districts is 34.5, slightly above the statewide ratio of 30.5. It is clear, even from this small sample of districts, that considerable differences exist in the distribution of computers among Texas school districts. Of course, the number of computers in a school certainly does not measure the quality of learning taking place. Nevertheless, if one is concerned with the access that students in Texas have to computers, these data may indicate a problem.

The distribution of computers in Texas school districts varies widely. Some of the variation may be due to choice: some districts may prefer to invest in salaries or in other kinds of curricular materials, and their programs may be stronger because of that choice. Other districts may want to purchase more computers but cannot find funding for them. It is difficult to determine district motivation without extensive contact with administrators. However, the data above show that there is a slight tendency for districts with low operating expenses per student to own fewer computers. This supports the conjecture that funding may be a problem for some districts. To back this up, QED's national research shows that low-wealth schools with small enrollments are likely to have fewer microcomputers at present. Therefore, the state of Texas may want to target such districts for additional funding if a statewide technology program is implemented.

COSTS OF EDUCATIONAL TECHNOLOGY

Educational technologies can be very costly to implement. Any new instructional program requires extensive resources for planning and development alone. Materials and teacher training also have costs. In addition, schools often have to pay for other services and items to implement technology, such as remodeling, rewiring, furniture, security, software, equipment maintenance, upgrading and replacing equipment and software, and higher utility bills. Teachers and administrators may also have to devote many hours to curriculum revision and independent work with the new equipment.

In the case of technological tools, such as microcomputers and telecommunications, equipment and training costs are likely to be higher than for more traditional classroom approaches. Educational technology is typically added on to other school expenditures. Splittgerber, Eubanks, and Stirzaker disagree with the myth that hardware and software purchases result in lower budgets and fewer personnel: "The patterns of staff personnel deployment across industry and education have required more staff and/or a redefinition of current job descriptions when computer hardware is purchased" (1987, p. 17). They argue that improved educational opportunities are the only good justification for spending on technology.

Total costs may vary a great deal, depending on prior circumstances and investments at the school. One source states that nonequipment costs such as training, maintenance, and facilities sometimes amount to as much as three times the investment in equipment (CERI/OECD, 1986, p. 87). Because technology changes rapidly, updating equipment and software and retraining staff to use it can become major ongoing expenses. Schools should not underestimate these costs. The price they pay for miscalculation is frustration with and underutilization of the equipment.

Generally, implementation of new technology will create research and development, capital, and operating costs. These costs usually can be clearly separated. Schools do not often incur research and development costs, unless they initiate their own courseware development projects. Research and development of equipment and courseware is usually financed by private firms for profit, although state agencies, regional consortia of districts, and nonprofit organizations sometimes undertake these activities. The Minnesota Educational Computing Consortium is an example of a state-initiated research and development body, and the Texas Learning Technology Group is a district-funded example.

School districts typically absorb the capital and operating costs of technology programs, although their funds come from a variety of local, state, federal, and private sources. Initial capital costs may be considered to include the expenses of equipment, requisite courseware, furniture, and construction or remodeling of facilities; that is, items which are tangible and have a relatively long life span. School districts often pay for the capital costs of new equipment from their operating budget or fund balance. According to Lewis Wilks of the Texas School Services Foundation, Texas districts tend to be very conservative in financial matters. They prefer pay-as-you-go financing whenever possible, and therefore may not consider other financing alternatives that may benefit them (telephone interview, June 27, 1988).

Operating costs cover frequently replaced items and ongoing services, including supplies, training and salaries, maintenance, and utilities. Because these items are not tangible or do not have a long life span, they must be paid for from a district's operating budget. These ongoing expenses may cost considerably more than capital expenses in the long run, but they are critical to the satisfactory integration of technology in schools.

To estimate the costs of investment in technological tools, one can examine the prices of high-quality equipment currently available. For example, in 1988, the cost of an IBM-compatible computer with monochrome monitor, one 40-megabyte hard disk drive, a modem, and a printer was $2,340 from vendors on the state contract (Geoffrey Fletcher, interview, February 11, 1988). To provide one workstation with this equipment for every 25 school children in Texas would cost roughly $299 million -- not including software, furniture, local area network, staff training, etc. A Macintosh SE communications workstation with similar equipment would cost $2,857 in 1988 with an educational discount in the largest volume order category, or nearly $366 million across the state. Clearly, these costs are substantial, especially if borne by the operating budget.

The cost of information technology has fallen dramatically over the years. Sullivan cites that the cost of one megabyte of memory in a component cost about $32,000 in 1974, $7,000 in 1977, $1,500 in 1980, and less than $300 in the early 1980s (1985, p. 42). This difference occurs because the technology used in computers has advanced very quickly. Miniaturization and large-scale integration of circuits has increased the number of transistors on a silicone chip from about 1,000 in 1970 to 256,000 in 1983, while attempts to develop a chip holding over 1,000,000 transistors continue. Ayres writes, "Costs have dropped as rapidly as microminiaturization has progressed" (1984, pp. 146-7). Educational technology benefits from such advances, and so school districts may pay similar or lower prices for better equipment in the future.

A BRIEF OVERVIEW OF PUBLIC SCHOOL FINANCE IN TEXAS

Texas public schools are financed by a combination of state, local, and federal funds, as indicated in table 3. In fiscal year 1986, 51 percent of funding came from local revenues. About 90 percent of local revenues are raised by the property tax, with the remainder coming from investment earnings, tuition charges, building use fees, gifts, food services, etc.

Table 3

Sources of Public School Funds, Fiscal Year 1986

	Amount	Percentage
Local	$5,250,542,433	49%
State	$4,554,388,606	42%
Federal	679,831,544	6%
Other	$330,703,053	2%
TOTALS	$10,815,465,636	99%*

Source: Walker, Billy D., and William Kirby. 1986. *The Basics of Texas Public School Finance*, 3rd ed. Austin: Texas Association of School Boards, p.30.

*Total percentage does not add to 100 percent due to rounding.

Property tax rates are divided into maintenance and debt service components. The state of Texas supplied 42 percent of 1985-86 school revenues through several mechanisms, including per student apportionment, Foundation School Program aid, categorical aid, and textbook funds. The remaining portion of funds, about 6 percent, comes from the federal government. Most federal monies are targeted for specific purposes, such as programs for handicapped students, educationally disadvantaged students, and vocational education.

State funds are funnelled primarily through the Foundation School Program (FSP), which is intended to provide a basic level of support for all districts, regardless of their level of wealth. Some features of this program attempt to equalize the wealth differences between districts by providing extra funds for poorer districts. However, the degree of equalization is not complete because wealthier districts often are able to add more local enrichment funds to FSP funding.

Both the state and local districts share in the FSP. In 1986-87, the FSP was based on an allotment of $1,350 per student established by the legislature. This amount was then adjusted to reflect variable costs of educational resources in districts. Upward adjustments were made for small and sparsely populated districts on the premise of diseconomies of scale. Special programs included compensatory education, special education, vocational education, gifted and talented programs, bilingual/English as a Second Language programs, transportation, and the education improvement and career ladder allotments. Funds for special allotments were calculated by multiplying the basic allotment ($1,350) by the number of students in the program , and then by a weight reflecting the program's relative costliness.

State funds for the FSP come from several sources. One source is the Available School Fund, which provides money for the per capita apportionment. In 1986-87, this guaranteed state aid delivered about $220 per student to each district. This apportionment represents a relatively small part of FSP funding -- about 10.5 percent in 1985-86. The per capita apportionment is the only FSP aid that the wealthiest districts receive; and it is mandated by the state constitution.

The local fund assignment is a second funding source. Each district is assigned a portion of the cost of the FSP based on the value of taxable property in the district. The third funding source is the Foundation School Fund, which provides state aid to any district which has a calculated program cost higher than the sum of the per capita apportionment plus its local fund assignment.

Separate FSP aid is available for categorical programs such as prekindergarten and education of visually handicapped students. Some of these funds are available on an application basis, while others are distributed according to formulas.

The final element of the foundation program is enrichment equalization aid. Districts with property wealth per student less than 110 percent of the statewide average property wealth per student are eligible for equalization aid. The amount received is tied to the amount of tax effort the district shows. This aid is meant to provide poor and average wealth districts the ability to raise revenue above the foundation program.

The state provides two other major forms of aid outside of the foundation program. It contributes the bulk of Teacher Retirement System funds, and it purchases textbooks for local districts. Textbooks are chosen by the districts from a list of state-approved titles.

OPTIONS FOR FINANCING EDUCATIONAL TECHNOLOGY

Public school funds typically come from only a few sources: local tax revenues, state appropriations, federal appropriations, and outside grants. School districts are usually highly constrained in raising local tax revenues. In Texas, school districts are limited to using the property tax as a local revenue source, aside from food service and cocurricular fees which provide a very small part of local revenues (Walker and Kirby, 1986, p. 33). In addition, districts are not permitted to increase property tax levies more than 8 percent a year without voter approval. Because property wealth is distributed unevenly throughout the state and because the property tax is an unfortunate source of revenue for a variety of reasons, the state has provided an increasingly large portion of school funding.

School districts commonly finance large capital outlays through bonds. Bonds offer a way to repay large sums from current revenues over many years. Financial wisdom requires issuing debt for a maturity that matches the useful life of the project being financed (Mikesell, 1986, p.441). However, equipment has a lifespan of three to ten years at most, which ordinarily creates problems in long-term financing. Bond financing is available through an innovative mechanism developed by the Texas Association of School Boards, which allows bonds to be issued for personal property. This approach offers a useful financing option to local districts.

Districts frequently look for outside grants to support new technologies. *Electronic Learning* suggests five computer funding sources: Apple Computer Grants, the National Science Foundation, federal grants, parent and local community groups, and Chapter 2 (federal block grant) funds ("One Hundred and One Things," 1988, p. 41). However, these are all temporary and supplemental sources of funds. Parent-teacher associations have often raised money for the first few computers placed in a school. Local businesses sometimes donate equipment or funds to schools. Splittgerber, Eubanks, and Stirzaker suggest that a business and a school can work together to open a computer service center in the school. The business supplies the software and hardware, and the school furnishes the room, utilities, and hardware maintenance. During daytime hours the center is used by the school, and during the evening the company offers computer classes to the community for a fee (1987, pp. 17-18).

Aside from business, grants may come from the federal government or private foundations. The U.S. Departments of Commerce and Education both offer competitive grants for telecommunications projects for which school districts are eligible to apply (Platz, 1987, p. 20). Federal Chapter 1 funds for disadvantaged children and Chapter 2 funds are also common sources of funding for technology.

Under the category of grants is the Adopt-A-School program, an example of business-school collaboration to produce better schools and to enlighten citizens about what the schools do. Because Adopt-A-School is operated on a local, school-by-school basis, it may not easily solve the problems statewide. However, it demonstrates the approach of appealing directly to business to intervene on behalf of schools. Businesses may also be willing to help implement larger goals on a statewide level.

State appropriations offer one of the most desirable sources of funding. However, the recent and possibly continuing fiscal crisis in Texas means that large sums of money may not be available for new initiatives in the near future. State attention is now devoted largely to solving overall problems of school finance equity. But it is possible that some part of the state's funding formulas could be adjusted to reflect the costs of installing and maintaining a system of technology. The obvious roadblock to such an approach is the need to have legislative approval for funding changes (and possibly for new taxes) and voter approval for any constitutional amendments.

Another topic related to financing is volume purchasing of equipment and site-licensing of software. The state has regulations which govern what items may be purchased under what procedures. The Texas Education Agency (TEA) arranged for districts to purchase computers on state contract, thus providing local districts access to volume discounts. However for the 1987-88 school year, the State Purchasing and General Services Commission changed its contract to allow purchase of only Apple and IBM-compatible computers (Geoffrey Fletcher, interview, October 15, 1987). Because school districts use a wide variety of computers, this change prevented a number of districts from making use of the state contract procedures to order equipment at cheaper rates. New arrangements could be made through the state or in a separate buying cooperative to make volume discounts available for a range of products.

Grants From Businesses

One type of business-education collaboration can be seen in Adopt-A-School programs such as the one that the Austin Chamber of Commerce and Austin Independent School District have jointly sponsored since 1983. In this program, area organizations agree to assist a particular school for one academic year. At the end of the year, the adoption may be renewed. Adopters typically are small or large businesses, but a number of civic groups, associations, fraternal organizations, and individuals also participate. The goal of the program is to involve the business community in the public school system via contributions of volunteer time, money, in-kind services, or equipment. Activities that promote student motivation and provide appreciation and assistance to teachers are also encouraged.

The degree of involvement and types of contributions vary widely in Austin. In 1986-87, most organizations donated both volunteers and goods or services. Volunteers usually served as tutors, but some also worked as library aides, guest speakers, or special event attendants (such as at carnivals or garage sales) or with the PTA or on advisory committees. Donated goods ranged from furniture to baseball caps, donuts to refrigerators. The program appears to place an emphasis on funding rewards and incentives for teachers and students. Teacher appreciation luncheons and pizza parties to reward students for good attendance were typical donations. Most schools have several adopters that provide different kinds of contributions. During the program's first $3^{1}/_{2}$ years, 48,140 volunteer hours were donated, as well as $541,345 in cash and $1,083,011 in goods and services (AISD and Austin Chamber of Commerce, 1987, p. 37).

Adopt-A-School programs are developed to meet the needs of school districts and individual schools. They do not seem well suited for a statewide initiative or to fulfill comprehensive plans, such as for a technology system, although the state could encourage their growth by introducing tax breaks for donations or by providing information and assistance. Adopt-A-School programs are often just as valuable in creating public support as they are in providing financial and in-kind support. They promote increased understanding of public schools through personal interaction with students, teachers, and administrators. However, because Adopt-A-School programs are valuable in their own right, they should not be forced to encompass such diverse goals as personal interaction and statewide fundraising.

The decentralized nature of adopt-a school programs with one-on-one relationships between many schools and many organizations, does not lend itself to massive projects. A different structure, with less emphasis on public relations goals will be necessary to solicit large contributions from the business community. Within a school, one or more adopters may be found to help purchase technological resources such as computers or a satellite dish. However, it is probable that only large or medium-sized firms will be able to afford substantial contributions. School districts without thriving business communities will be at a disadvantage, and total donations may not stretch to cover the needs of all schools in a district. To accomplish major district goals, a strong district-wide planning structure, considerable business support, and several years probably will be necessary.

Other types of business-school collaborations may better provide the amount of support needed for major goals. One typology lists eight kinds of partnership programs (Peck, 1987, p. 29). Of these, the philanthropic foundation established by business, civic, or school leaders seems most appropriate for large projects which cannot summon adequate district funding. A national entity called the Public Education Fund has encouraged the growth of local funds by awarding matching grants (Peck, 1987, p. 31). A statewide foundation for donations may be feasible. Business officials often want to see a direct benefit from their donations and to feel that they have some input into expenditures. Such a foundation must promote a goal which has widespread public and business support, and it should allow business representatives to help plan the project.

Bond Financing

Texas school districts generally finance the purchase of personal property with lease/purchase contracts or with cash from operating revenues (Russ Edwards, interview, November 17, 1987). Bank loans are feasible but interest costs are higher than for bonds, which are tax-exempt and thus carry lower rates. Lease/purchase interest rates are also at high commercial levels. During hard financial times like the present when tax bases decline, cash may not be readily available for purchases that are not absolutely necessary.

Computers, satellite dishes, and almost every other type of educational technology are considered moveable personal property. In the past, school districts have been somewhat limited in the possible methods of financing such items. Long-term general obligation bonds require costly legal fees and election expenses. In addition, the lifespan of equipment is generally far shorter than the maturity period of a typical bond issue. School districts frequently include equipment and furnishing costs in bonds that finance building construction. But bonds issued for equipment alone are impractical. It is very costly to issue bonds for less than $1 to $2 million (Lewis Wilks, telephone interview, June 27, 1988). For this amount a district could purchase roughly 500 to 1,000 personal computers, a number far larger than the typical district would usually want to buy. Therefore, bond issues are not a common way to finance technology purchases.

The Texas School Services Foundation (TSSF), an arm of the Texas Association of School Boards, recently has begun to administer a program that enables school districts to finance personal property through bonds while pooling the issuance costs. The Capital Acquisition Program (CAP) has overseen the issue of $8.745 million in bonds for 18 Texas districts since August 1987 (Lewis Wilks, telephone interview, June 27, 1988). Authorized by the Interlocal Cooperation Act (Vernon's Annotated Texas Civil Statutes, Article 4413[32c]), the Public Property Finance Corporation of Texas was established to issue bonds for school districts.

The chief advantages of the program are the ability to spread financing over the useful life of a piece of property, however long that is, obtain lower interest rates, and pool bond-issue costs. Any school district may participate. TSSF anticipates that many more districts will join as sponsors and participants in the future; another large issue is being planned for August 1988. Each participating district is liable only for its own borrowing and pro rata share of program and bond issue expenses. TSSF conducts the daily operations of the program, surveys districts for program needs, and reports these needs to the financial advisor and underwriter. School districts are responsible for complying with any regular procedural or legal requirements for financing property or assuming debt, such as competitive bidding regulations and tax levy laws (TSSF pamphlet).

So far the Capital Acquisition Program has been used by a mix of districts with varying enrollment and wealth levels and from different areas of the state (Lewis Wilks, telephone interview, June 27, 1988). CAP is a good financing mechanism for equipment purchase if the state decided not to contribute to the capital costs of a technology program, but it does not address the operating costs incurred by such a program. State aid might be necessary to ensure that districts undertake adequate planning and teacher training. The reasonable financing terms that it offers probably would make equipment acquisition possible for a large number of districts. Even so, some might need subsidies to participate, particularly if their debt service levels were already high or at the legal limit. The state could provide grants to these districts or underwrite the higher costs of credit enhancement for districts with poor credit ratings.

FINANCING OPTIONS AT THE STATE LEVEL

Foundation School Program

Adjustments to provide funding for technology could be made within the formulas used to allocate state funds to schools through the Foundation School Program (FSP). A number of programs, including special education, vocational education, and transportation costs, are already funded through special entitlements added to the basic entitlement of the foundation program. Most of these entitlements are calculated by multiplying the number of full-time equivalent students enrolled in a given program by the adjusted basic allotment per student, and then multiplying by a weight which is supposed to indicate the relative costs of providing the program. For example, the weight for vocational education is 1.45, and the weight for homebound instruction is 5.0 (Walker and Kirby, 1986, pp. 34-35). Thus, the higher costs of offering such programs are taken into account when TEA calculates a district's need for state funds.

Similarly, a weight can be established for the costs of providing some types of technology in a district. Because a weight is uniform for all schools in the state, it could only roughly estimate the cost of providing technology. However, its existence in the funding formulas will be an incentive for districts to implement those types of technologies. As special entitlements are calculated now, the funding would not be available for all students. Funds are made available for a specific number of students enrolled in a specific program of study. Such a funding mechanism would not be appropriate for a school-wide goal such as providing one computer for every ten students. However, it would be well suited to funding limited programs using technology, such as classes taught via distance education (Tom Patton, telephone interview, June 27, 1988). To ensure that funds are being spent appropriately, the state should specify that only certain types of technology programs are eligible for special entitlement funding.

Establishing the weight in an objective fashion will probably require some cost analysis of existing programs. The weight can only roughly approximate the cost of providing a program because of the wide variety of types of educational technology and software and the many different ways in which schools structure their programs.

A grant for technology programs can also be established as an add-on to the Foundation School Program after the local share has been deducted from the FSP budget. Using this formula, the state would entirely fund the program for all districts. By containing the program costs within the FSP, wealthier districts would not receive state aid for it while poorer districts would. The add-on device would ensure that all districts receive funding, which might be appropriate if the state considered the program mandatory or otherwise gave it a very high priority. However, the add-on would not be the most equitable option for directing extra funds to poor districts. No matter how funding through the Foundation School Program is structured, it will require new state appropriations or transferring funds from other education programs.

Permanent School Fund

The Permanent School Fund (PSF) is an endowment dedicated to the support of public education in Texas. First established in 1854, it was eventually endowed with many millions of acres of land and mineral rights, including the state's oil-rich coastal tidelands. Its current funds are invested in high-yield securities, chiefly corporate stocks and bonds and U.S. Treasury bonds, although investments in municipal and school district bonds also are allowed. A 1963 state constitutional amendment prohibits spending the fund's principal. PSF earnings are constitutionally required to be apportioned annually to school districts on a per student basis (Walker and Kirby, 1986, pp. 3, 18).

The Permanent School Fund is the largest endowment in the world devoted solely to education. As of June 30, 1988, the market value of PSF investments was about $7.6 billion. In 1987, the PSF contributed $185 per student in earnings to state education funds (Jim Hooks, telephone interview, July 6, 1988). Annual income is now about $595 million, which constitutes approximately 15 percent of the state's total funding for public elementary and secondary education (Tom Patton, telephone interview, June 27, 1988).

Permanent School Fund Earnings. One way for the state to fund an educational technology program is to use some or all of the PSF earnings for that purpose. These earnings now are mandated constitutionally to be apportioned strictly on a per pupil basis. It might not require any constitutional changes to devote a portion of that funding to technology development in schools, out of the same per pupil apportionment. In this case, every school would receive a proportionate allotment for technology, the amount depending on enrollment. Flat funding of this sort has drawbacks in terms of effectiveness and equity, however.

Funds are often spent ineffectively when schools are required to spend money on a program, whether or not they need the program or the money. Some schools already have well-developed technology programs with adequate sources of funding. Other schools have only minimal technology programs. Some of these schools would be able to pursue technology plans immediately, given new funding, while others would not be prepared to make acceptable plans and purchases.

Equity would not be served because such funds would be distributed on a per pupil basis regardless of how much the school has already invested in a technology program. To achieve equity in terms of actual technology investments would require giving more funding to those schools with less well developed technology programs, regardless of their enrollment.

A major drawback of allocating a portion of present PSF earnings to a technology program is that districts would have *less* state funding from this source to meet their other needs. Also, some districts may be able to effectively achieve their goals through means other than technology. Therefore, funding for technology would not necessarily help them to improve.

A constitutional amendment could disengage PSF earnings from allotment on a per ADA basis. Another basis could be used to allocate these funds (as written into the constitution or legislation), such as allotment according to some indicator of need or student achievement, or for good technology plans. The latter would resemble a categorical grant. This mechanism may be more equitable and more effective than allocation on a per pupil basis. If targeted to schools with financial need, the program will be equitable with regard to finance. If targeted to schools with low student performance, the program can address equity in outcome, that is, student achievement. To achieve effectiveness, the funding should be directed towards schools which demonstrate that they have a desire to use technology and that have satisfactory plans for implementation.

Investment of Permanent School Fund Principal. Alternatively, the body of the PSF could be used to help finance a technology program in other ways. It would be unwise, as well as constitutionally prohibited, to spend the PSF's principal. However, part of it could be used to invest in ventures which could benefit the program. Development of educational software is an obvious area for such investment. Commercial developers have published a proliferation of software packages for schools, but many of them are of poor quality or do not exactly fit the needs of individual schools and teachers. Through investment in a consortium or corporation which is responsive to the needs of Texas schools, the cost of producing better quality and more suitable software could be underwritten. These products could then be marketed to schools and education agencies in other areas of the country, as well as Texas.

Such a venture would undoubtedly entail some risk for PSF funds invested in it. However, means may be found to reduce the risk. Perhaps other states would be willing to share in capital costs, thereby reducing the amount of investment for Texas and increasing the potential market for products and profits. Other benefits, such as licensing the resulting software, would reduce state costs in certain areas. Because such an investment would probably reduce the income of the PSF, the state could appropriate funds for such an investment instead.

The PSF may also be used to underwrite loans or bonds to school districts to finance the purchase of equipment. To be beneficial to schools, the interest charged would have to be lower than that available through other sources. Consequently, this would reduce the annual income from PSF investments. Whether this is a worthwhile investment would therefore depend on whether the savings to school districts were larger than the loss of PSF earnings. In this case also, state appropriations could be used to set up a fund to make such loans to schools. Unlike most appropriations, this would return to the state with some interest while at the same time providing low-cost financing to districts.

Textbook/Software Funds

Currently, Texas provides free textbooks to all districts. In 1985-86, over $69 million from the Available School Fund was spent on textbooks (Walker and Kirby, 1986, p. 28). Under some interpretations, these funds can also be used to purchase educational software, since software is sometimes used as a substitute for textbooks. If it were considered appropriate, the State Board of Education could add software titles to the approved textbook titles list from which districts choose materials. Adding software titles to the approved lists would be another way to support technology in the schools. By using such a mechanism the state would provide little direction concerning the use of technology, except in providing an incentive to use equipment compatible with the listed software.

Drawbacks to such an approach include the neglect of new or nonreviewed software titles during the period of time in which a given list is effective. Software publishers tend to change their products often, and new products are constantly streaming onto the market. The volume of educational software is enormous. Updating the list only once a year or less frequently would bias use in favor of older titles and certain publishers. It is possible that publishers would adapt to this by changing the timing and frequency of product releases, however, since Texas schools would then form a large market.

Innovation Fund

Texas might consider using a state funding system more akin to a grant. The key element of the grant is that it would be tied to student performance gains. In the beginning, every district might be eligible for some funding, but continued funding would be tied to some measure of effectiveness, such as improvement in student performance on the TEAMS test. A second dimension of eligibility might involve the submission of a satisfactory plan for use of the technology grant. The benefits of such a program would include a necessary component of local planning to ensure more successful local programs; local enthusiasm for the program because it is planned to suit that district; a strong element of built-in accountability in terms of improving student performance; and the promotion of equity in terms of trying to achieve high student performance through the best means available.

Since each project would be different, the fund would not be appropriate for a uniform statewide plan or technology infrastructure. Equity in terms of equal allocation of resources would not be given priority in this plan; instead, districts would receive varying amounts according to the degree of gains in student achievement, the availability of funds, and the quality of their plans. A drawback to this idea is that it would require new state appropriations unless funds were transferred from another area.

The innovation fund could be designed primarily to assist districts that show weak student performance, because they are the districts with the most to gain from such a program. Since these districts are also likely to serve poor families, the innovation fund would provide a form of state equalization funding. Initial funding could be targeted primarily to districts with weak student achievement on the the basis of need in the first round. Continued funding would depend on gains achieved thereafter. In awarding the grants, improvement should not be compared to some stationary "good" test score, but rather for measured net gains in performance.

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LIST OF ACRONYMS

AACTE	American Association of Colleges for Teacher Education
ADA	average daily attendance
AISD	Austin Independent School District
BSAP	Basic Skills Assessment Program (South Carolina)
CAI	computer-assisted instruction
CAP	Capital Acquisition Program, Texas School Services Foundation (a division of Texas Association of School Boards)
CCC	Computer Curriculum Corporation
CCP	Comprehensive Competencies Program
CERI/OECD	Centre for Educational Research and Innovation, Organization for Economic Development and Cooperation
CETA	Comprehensive Employment and Training Act of 1973
CMI	computer-managed instruction
CMS	Classroom Management System (South Carolina)
CSTP	Commission on Standards for the Teaching Profession
EIA	Educational Improvement Act of 1984 (South Carolina)
ERIC	Educational Resources Information Center
ETS	Educational Testing Service
EXCET	Examination for the Certification of Education in Texas
FCC	Federal Communications Commission
FSP	Foundation School Program
IDRA	Intercultural Development Research Association
IPT	Information Processing Technology (a special endorsement for teachers)
ISD	Independent school district
ITBS	Iowa Test of Basic Skills
ITFS	instructional television fixed service

ITV	instructional television
JTPA	Job Training Partnership Act of 1982
MDTA	Manpower Development and Training Act of 1962
MSSBA	Missouri State School Board Association
NBSD	National Test of Basic Skills
NCTM	National Council of Teachers of Mathematics
NDN	National Difusion Network
OSU	Oklahoma State University Telecommunications Instructional Network
OTA	Office of Technology Assessment, U.S. Congress
PEIMS	Public Education Information Management System (Texas)
P-PST	Pre-professional Skills Test
PSF	Permanent School Fund
QED	Quality Education Data, Inc.
SCETV	South Carolina Educational Television Network
SEED	Software Evaluation Exchange Dissemination Project
SWTSU	Southwest Texas State University
TEA	Texas Education Agency
TECAT	Texas Examination of Current Administrators and Teachers
TI-IN	TI-IN Network, Inc.
TLC	Teaching and Learning with Computers (IBM Corporation)
TLTG	Texas Learning Technologies Group
TSSF	Texas School Services Foundation
TTAS	Texas Teacher Appraisal System
VCR	videocassette recorder

COMPLIANCE STATEMENT

TITLE VI, CIVIL RIGHTS ACT OF 1964; THE MODIFIED COURT ORDER, CIVIL ACTION 5281, FEDERAL DISTRICT COURT, EASTERN DISTRICT OF TEXAS, TYLER DIVISION

Reviews of local education agencies pertaining to compliance with Title VI Civil Rights Act of 1964 and with specific requirements of the Modified Court Order, Civil Action No. 5281, Federal District Court, Eastern District of Texas, Tyler Division are conducted periodically by staff representatives of the Texas Education Agency. These reviews cover at least the following policies and practices:

(1) acceptance policies on student transfers from other school districts;

(2) operation of school bus routes or runs on a non-segregated basis;

(3) nondiscrimination in extracurricular activities and the use of school facilities;

(4) nondiscriminatory practices in the hiring, assigning, promoting, paying, demoting, reassigning, or dismissing of faculty and staff members who work with children;

(5) enrollment and assignment of students without discrimination on the basis of race, color, or national origin;

(6) nondiscriminatory practices relating to the use of a student's first language; and

(7) evidence of published procedures for hearing complaints and grievances.

In addition to conducting reviews, the Texas Education Agency staff representatives check complaints of discrimination made by a citizen or citizens residing in a school district where it is alleged discriminatory practices have occurred or are occurring.

Where a violation of Title VI of the Civil Rights Act is found, the findings are reported to the Office for Civil Rights, U.S. Department of Education.

If there is a direct violation of the Court Order in Civil Action No. 5281 that cannot be cleared through negotiation, the sanctions required by the Court Order are applied.

TITLE VII, CIVIL RIGHTS ACT OF 1964; EXECUTIVE ORDERS 11246 AND 11375; TITLE IX, 1973 EDUCATION AMENDMENTS; REHABILITATION ACT OF 1973 AS AMENDED; 1974 AMENDMENTS TO THE WAGE-HOUR LAW EXPANDING THE AGE DISCRIMINATION IN EMPLOYMENT ACT OF 1967; AND VIETNAM ERA VETERANS READJUSTMENT ASSISTANCE ACT OF 1972 AS AMENDED IN 1974.

It is the policy of the Texas Education Agency to comply fully with the nondiscrimination provisions of all federal and state laws and regulations by assuring that no person shall be excluded from consideration for recruitment, selection, appointment, training, promotion, retention, or any other personnel action, or be denied any benefits or participation in any programs or activities which it operates on the grounds of race, religion, color, national origin, sex, handicap, age, or veteran status (except where age, sex, or handicap constitute a bona fide occupational qualification necessary to proper and efficient administration). The Texas Education Agency makes positive efforts to employ and advance in employment all protected groups.